Additives And Blends of Biodiesel

Ojo E. Olufisayo,
Professor Freddie Inambao*
Department of Mechanical Engineering
University of KwaZulu-Natal, Durban 4000, South Africa

ABSTRACT

Biodiesel, an alternative to diesel fuel, has gained significant attention due to its renewable and environmentally friendly characteristics. However, it is not without its drawbacks, such as higher density, lower heating value, increased fuel consumption, and higher emissions of oxides of nitrogen (NOx). To overcome these challenges and ensure compliance with international fuel standards, researchers have explored the use of additives and blends in biodiesel. This article aims to provide an overview and examine the various additives and blends of biodiesel commonly used in biodiesel production, and their applications/effects on performance and emissions, drawing from various studies and sources [1 – 7].

Keywords: Biodiesel, biodiesel production, Additives and Blends, Engine Performance, Exhaust Emissions.

1.0 INTRODUCTION

Global warming concerns and strict emission regulations are the main driving force of the present engine development efforts. Finding low emission solutions, such as different combustion modes, after-treatment technology, and sustainable alternative fuel sources, is the focus of efforts to achieve these targets. Biodiesel produced by transesterification from plant and animal sources is regarded as a competitive substitute for fossil fuel diesel. Depending on the production process and the feedstock utilized, biodiesels show a considerable variation in composition. The renewable biodiesels have been under active consideration for replacing fossil diesel due to the proximity of their properties and minimum engine hardware modifications. Biodiesels derived from fatty acids of plant or animal origin exhibit significant composition variations depending upon the feedstock used for production. The oxides of nitrogen (NOx) emission from biodiesel are higher than diesel and remain a significant concern [8]. Biodiesel is becoming increasingly popular. However, it is often necessary to add certain compounds to ensure that biodiesel performs to its full potential and meets regulatory standards. These additives and blends can improve the properties of biodiesel, such as its stability and emissions performance. There are different types of additives and blends available, each with its specific function. may be used to improve low-temperature performance, while others can enhance oxidative stability or reduce engine deposits. Understanding the types of additives and blends, and their effects on biodiesel performance, is crucial for anyone involved in using this alternative fuel [9 – 12]. Additives and blends are important in biodiesel production and enhancement. They are used to improve fuel efficiency and compatibility with other fuels. Additives such as antioxidants, cetane improvers and cold flow improvers are added to improve fuel quality and prevent degeneration of quality. Biodiesel can be blended with petroleum diesel or other biofuels to improve fuel properties such as cold flow, viscosity and lubricity. The fuel properties of a blend are determined by the nature of the biodiesel and the blending agent used in the process. Therefore, the use of right additives and blends compatible with biodiesel production and fuel storage/transportation equipment is critical. Through the use of additives and blends, biodiesel can meet specific application requirements and improve overall sustainability [13 – 18].

2.0 BIODIESEL

Biodiesel is a renewable fuel alternative to conventional petroleum-based diesel fuel. It is a complex mixture of esters with different chain lengths and degrees of saturation and can be used blended (up to 20%) with diesel without major modifications in diesel engines. The quality of biodiesel is related to several physio-chemical properties, such as ignition quality, heat of combustion, cold flow, oxidative stability, viscosity, density, and lubricity The process of producing biodiesel involves a chemical reaction between vegetable oils or animal fats and alcohols to produce esters in a process known as esterification [19 – 21]. However, additives and blends are substances or chemicals required to advance the quality of the produced biodiesel fuel. Biodiesel is also often blended with petroleum diesel to create a blend that improves the performance blend and reduces the emissions from the use of the blend. The percentage of biodiesel in a blend affects the resulting fuel properties such as cetane number, viscosity, and strength. Understanding the properties of additives and blends is important in the production and use of biodiesel as an alternative source [22 – 25].

Biodiesel is a new type of fuel that is rapidly gaining popularity due to its many environmental benefits. Additives are often added during production to improve biodiesel performance and stability. Additives are chemicals that are added to diesel to improve its performance and reduce any negative impact on the environment. These include antioxidants, corrosion inhibitors, cold flow improvers and detergents. Additives are usually added in small amounts, but they play an important role in maintaining the quality and longevity of biodiesel. Without additives, the quality of biodiesel can deteriorate rapidly, reducing its efficiency as a fuel source. The selection of appropriate additives is therefore an important part of biodiesel production and can significantly influence the success of the final product [26 – 29]

3.0 ADDITIVES

Additives play an important role in optimizing the characteristics of biodiesel, and as result improves its overall appearance and efficiency. These additives are mainly used to improve the cold flow, lubricity, oxidative stability and viscosity of biodiesel. They are also used to reduce negative effects such as filter plugging, injector fouling and corrosion. These additives are generally divided into two main categories: Flow Improvers and Oxidation Stabilizers. Flow Improvers improve the flow rate of biodiesel, especially at low temperatures, while oxidation stabilizers delay the onset of biodiesel oxidative degradation A wide variety of additives are available on the market, and the choice depends largely on the type, application and application of biodiesel [30 – 34].

3.1 EFFECTS OF ADDITIVES ON BIODIESEL:

Additives play a crucial role in minimizing the drawbacks of biodiesel and improving its combustion performance. Different types of additives have been applied to biodiesel to meet specification standards and enhance its quality. Metal-based additives, cetane number additives, antioxidant additives, and oxygenated additives have shown promising results in improving the quality of biodiesel. Metal-based additives have been found to improve combustion efficiency and reduce emissions. They act as catalysts, enhancing the oxidation of hydrocarbon molecules in biodiesel. Cetane number additives, on the other hand, improve the ignition quality of biodiesel, resulting in better combustion and reduced emissions. Antioxidant additives help prevent the degradation of biodiesel during storage and usage, ensuring its stability and performance. Oxygenated additives, such as alcohols, can improve the cetane number and reduce emissions by promoting more complete combustion [30 – 34].

3.2 TYPES OF ADDITIVES

Additives are substances added in small quantities to enhance or change the properties of a biodiesel. Additives account for the overall properties and performance of a biodiesel fuel. A variety of additives have been used to produce biodiesel, each with a specific purpose. Some of the additives are used to increase fuel lubricity, while others are used to improve cold whether efficiency and reduce emissions. For example, antioxidant additives are added to biodiesel to prevent oxidation which can deteriorate the quality and performance of the fuel over time. Additionally, some additives are used to improve the storage stability of biodiesel and reduce the risk of bacterial growth. Additives are important components in the production of high-quality diesel [35 - .46]

3.2.1 ANTIOXIDANTS

Antioxidants are additives used in biodiesel to improve its oxidative stability and slow its degradation over time. Oxidation of biodiesel produces harmful chemicals that reduce its quality and cause engine failure, filter clogging and fouling. Antioxidants work by delaying or inhibiting the oxidation reaction, thus prolonging the life of biodiesel. There are two main types of antioxidants commonly used in biodiesel: Synthetic Antioxidant and Natural Antioxidant. Synthetic antioxidants are generally phenolic compounds while natural antioxidants are those derived from vegetable oils or other sustainable sources. The selection of the antioxidants depends on factors such as the type of feedstock used to manufacture the diesel and the intended use of the fuel. Antioxidants are important components of biodiesel blends to ensure dependable performance that complies with industry standards [47 – 61].

3.2.2 ANTIFOAMING AGENTS

Antifoaming agents are a category of additives used in biodiesel blends to prevent the formation of foams during production and storage. Foaming of biodiesel can leads to complex situation such as blockage in pipeline and storage, resulting in performance problems and decreased productivity [67 – 69]. Antifoaming agents are generally added to the biodiesel blend during the production process and act to reduce the surface tension of the fuel thereby preventing foam development in the fuel [62 – 66]. Antifoams are usually made from silicone or other synthetic chemicals and must be prudently selected and controlled to ensure that they do not cause adverse effects on the performance and quality of the biodiesel. Although only a small quantity of the antifoaming agent is required in biodiesel blend, it plays an important role in ensuring the efficiency, safety and reliability of biodiesel [68 - 71]

3.2.3 CORROSION INHIBITORS – COLD FLOW IMPROVERS

Two additives, corrosion inhibitors and cold flow improvers, are the two commonly blended additives into biodiesel fuel products. Corrosion inhibitors are a protective coating on metal, preventing corrosion. This is especially important in high-water fuels, as water is a corrosive agent. Cold flow improvers, however, act to improve fuel performance at low temperatures by preventing fuel from gelling or solidifying at low temperatures Adding these two additives makes the synthesized biodiesel fuel corrosion resistant and able to operate continuously at different temperatures, making it a dependable and efficient fuel source [80, 89].

3.2.4 DETERGENTS

Detergents are one of the most important additives in biodiesel production. These detergents help keep the engine clean by removing existing deposits and preventing new ones from forming. Biodiesel fuels containing detergents have improved lubrication property and provide very stable combustion. Chemical detergents also help reduce particulate matter and NOx emissions from diesel engines. There are several types of detergents that can be used in biodiesel production, such as alkaline and acidic detergents. The quantity and type of detergent employed in biodiesel production can vary depending on the feedstock and desired properties of the biodiesel fuel. Generally, detergents are used in biodiesel production to maintain the engine performance and reduce harmful emissions [90 – 97].

3.2.5 DETERGENTS – LUBRICITY IMPROVERS

Detergents have become important additives in biodiesel production to overcome formation of deposit and injector fouling problems. The agent in fuel injectors help inhibit deposits formation in fuel injectors and combustion chambers and reduce emissions. In addition to cleaning, detergents also act as effective lubricity improvers, increasing the lubricating properties of the fuel to protect the engine. Some common detergents in biodiesel are mixtures of succinimide, amide, and polyisobutenyl succinimide. Lubricity improvers fuel lubrication to prevent corrosion of engine parts. it is commonly used in low-blend biodiesel fuels, as it increases fuel lubrication ability to meet engine lubricity requirements. The most common type of lubricity improvers is fatty acid methyl ester (FAME) derived from vegetable oils [98 – 111].

4.0 BLENDS

Blends refers to the mixture of biodiesel with petroleum diesel. Common blend used is B20 (20% biodiesel and 80 petroleum diesel). Many more blends than B20 are available, such as B50 (50% biodiesel and 50% petroleum diesel) and B100 (100% biodiesel). Blends with higher biodiesel content have better emissions profiles and are generally more environmentally friendly [6, 16, 32, 112, 113]. The blends with higher petroleum-diesel can operate well in cold weather and are readily available. Blends are commonly used to solve the problems of cold-weather operation, reduce emissions, and expand biodiesel availability. Blending biodiesel with petroleum diesel is a common practice and give access to everyone to use biodiesel even if it is not readily available locally. Biodiesel blending with petroleum diesel has emerged as a viable solution to produce fuel blends with specific characteristics. This blend is characterized with better-quality combustion and generates lower emission of carbon monoxide, hydrocarbons and particulate matter. In addition, the blends can be used in existing diesel engines without any major modifications. The blends are usually classified according to the percentage of biodiesel content in them, with B20 (20% biodiesel, 80% diesel) and B5 (5% biodiesel, 95% diesel) being the most common. However, certain factors such as fuel compatibility, storage and handling need to be considered when blending fuels [114 – 125].

4.1 EFFECTS OF BLENDS ON BIODIESEL

Blending biodiesel with other fuels, such as kerosene, diesel, or alcohols, can also have a significant impact on its performance and emissions. Blends of biodiesel with kerosene have been tested in diesel and aircraft engines, aiming to approach the properties of biodiesel to diesel fuel. These blends have shown promising results in reducing emissions of nitrogen oxides (NOx), particulate matter (PM), and carbon monoxide (CO) compared to pure diesel fuel. Blends of biodiesel with alcohols, such as methanol and ethanol, have also been studied. Biodiesel-methanol blends have been found to be more effective in reducing NOx and PM emissions compared to biodiesel-ethanol blends. Additionally, the addition of antioxidant additives to biodiesel blends has shown a reduction in NOx emissions. Conclusion: The use of additives and blends in biodiesel has shown great potential in improving its combustion [126, 117, 120 - 123]

4.2 TYPES OF BLENDS

Biodiesel can be blended with petroleum diesel in many ways. There are two types of blends: Bxx and Bxx+. Bxx is a blend indicating the percentage of biodiesel in the blend. For example, B20 has 20% biodiesel and 80% petroleum diesel. Bxx+ is a mixture containing more than xx percentage of biodiesel. B100 is an example of a Bxx+ blend, which contains 100% biodiesel and no petroleum diesel. The percentage of biodiesel in blends affects the inherent properties of the fuel such as viscosity and energy. Biodiesel blends are increasingly popular because they can reduce greenhouse gas emissions, improve engine performance, and promotes energy security. Blending biodiesel with petroleum diesel requires cautious consideration of properties of fuel, storage, and distribution facilities [112 - 124].

4.2.1 B5: 5% BIODIESEL AND 95% PETROLEUM DIESEL – B20: 20% BIODIESEL AND 80% PETROLEUM DIESEL

B5 and B20 are the two common blends of biodiesel and petroleum diesel. B5 is 5% biodiesel and 95% petroleum diesel, while B20 is 20% biodiesel and 80% petroleum diesel. These blends are growing in popularity, due to their environmental benefits and ability to reduce fossil fuel consumption. Biodiesel is a renewable fuel derived from vegetable oils or animal fats, and its use in diesel engines has been demonstrated to reduce emissions of carbon monoxide, particulate matter and other pollutants. The quantity or percentage of biodiesel in a blend describes the level of emissions reduction and the general environment impact of the blend. B5 and B20 are among the most widely used blends in the transportation industry, and their use is expected to increase gradually in the coming years [127 – 134].

4.2.2 B100: 100% BIODIESEL (PURE BIODIESEL)

B100 or pure biodiesel is a fuel made from renewable sources such as vegetable oils, animal fats, and other naturally occurring compounds. In most diesel engines, its usage is possible without any engine modification, and it has been shown to reduce greenhouse gas emissions and other harmful pollutants when compared to conventional diesel fuel. B100 is biodegradable and non-toxic, making it an environmentally friendly option. However, B100 may have some disadvantages such as higher cost and lower energy density compared to petroleum diesel. In addressing these issues, numerous blends of biodiesel and petroleum diesel have been advanced, offering some of the advantages of biodiesel while maintaining the comparative advantages of low cost and high energy density. B100 is still a significant alternative fuel option for individuals and organizations seeking to reduce their environmental impact [127 – 134].

5.0 BLEND OPTIMIZATION

The optimization of biodiesel blends is an important step as it helps to achieve desirable fuel characteristics and reduce costs. The goal of the blend optimization by blending different biodiesel feedstocks and petroleum diesel in specific ratios is to improve fuel properties such as viscosity, cloud point, cetane number, and oxidative stability. The primary objective of the optimization is to use cheaper feedstocks while maintaining the quality standards. This is attained through laboratory tests and analysis of different feedstock while considering production costs, stock availability and environmental regulation. Appropriate blend optimization will result to enhanced engine performance, lower emissions, and more reliable engine operation [138 – 147].

Optimizing biodiesel blends has gain popularity due to varying properties of biodiesel blends developed as result of different feedstock and method of processing used. The best blend ratio depends on factors such the feedstock used and the desired fuel properties to be achieved. It is therefore important to optimize the blend ratio to achieve the desired fuel characteristics that improve engine performance. Furthermore, blending biodiesel with diesel helps to reduce dependence on fossil fuels and consequently helps to protect the environment. Additions of additives and blends to biodiesel can significantly increase the fuel efficiency which means that less fuel will be required to cover same distance leading to cost savings and reduced carbon emissions. For instance, the use of antioxidants in biodiesel prevent harmful deposit formations and increase fuel life [135 – 137, 140 -145]. Similarly, the usage of additives such as lubricity and cetane improvers improve combustion and leading to a better fuel efficiency over time. Biodiesel has become a more viable and sustainable option to conventional petroleum-based fuels but requires careful selection of appropriate additives and blends to achieve best result. Biodiesel is widely regarded as a cleaner fuel than conventional fossil fuels. One of the main reasons is its ability to reduce the emission of harmful pollutants. Compared to conventional diesel, biodiesel contains less amount of sulfur, carbon monoxide and particulate matter. Furthermore, the use of biodiesel in existing diesel engines has been shown to significantly reduce carbon dioxide and other greenhouse gas emissions because biodiesels are made from renewable sources such as vegetable oils or animal fats that absorb carbon dioxide during growth or maturation. Diesel can therefore play an important role in reducing the environmental impact of transportation and the use of other diesel engines applications [152 – 163].

5.1 CONDITIONS AND FACTORS TO CONSIDER WHEN OPTIMIZING BIODIESEL BLENDS

There are many considerations when designing or optimizing a high-quality biodiesel blend. These include: the desired properties of the fuel blend to be achieved, suitability of feedstock, applicable material regulations and standards, the availability of materials, and the production costs. Using different additives and different blending method can affect the performance and stability of biodiesel blends To ensure the highest fuel quality, It is important to carefully balance these factors before specifying a blend for any particular application.

For successful blending of additives with biodiesel, certain conditions must be satisfied which include: the right temperature, the right mixing method and the right pH level. The ambient temperature range should be 100-120°F for proper blending and flow. Mixing should take several hours to ensure that the additives are evenly mixed. Furthermore, the pH values should be carefully adjusted as necessary to guarantee the stability and longevity of the mixture. Factors such as additive type, biodiesel source, and end-use may also influence the specific conditions required for successful blends. It is necessary to adhere to the suitable conditions to produce high-performance and environmentally friendly biodiesel blends. The conditions to be considered when optimizing biodiesel blends include [141 – 150]:

5.1.1 EQUIPMENT COMPATIBILITY

Equipment compatibility is an important factor in the production and use of biodiesel. Some additives used in biodiesel may not be compatible with some equipment resulting in maintenance issues and reduced performance. It is crucial to ensure that the equipment used in biodiesel production is specifically designed for the feedstock and additives used. Equipment compatibility issues can arise due to differences in fuel viscosity, flash point, or lubricity. To avoid potential problems, compatibility testing should be performed prior to full-scale production. Additionally, the equipment used to transport or store biodiesel must be compatible with the fuel to avoid degradation or contamination. Equipment compatibility can also help improve the overall quality and efficiency of biodiesel production [141 – 150].

5.1.2 AVAILABILITY

The availability of additives and blends has played an important role in the ongoing growth and expansion of the biodiesel industry. Over the years, the market for biodiesel additives and blends has grown, and many companies are increasingly involved in the production of these products. These additives are readily available, and offered by many companies at inexpensive prices, making them easy for biodiesel producers to obtain and use. However, biodiesel additives and blends are scarce in some regions, and producing companies have trouble finding suppliers in their locality. The availability of certain blends and additive types depend on the feedstocks employed in the biodiesel production which may be area specifics. Despite these boundaries, the trend towards more and environmentally responsible fuel options means that the demand for biodiesel additives and blends is likely to increase in the future [141 – 150].

6.0 BLENDING PROCESS

The blending process is a crucial step in producing high-quality biodiesel. This process involves combining the biodiesel fuel with other additives compatible fuels to achieve the desired performance and characteristics. Blending can improve engine performance and reduce emissions. The process includes selecting the appropriate blend ratio, blending methods, and equipment to achieve the desired result. The most commonly used blending is splash blending, where the fuels are mixed together in a tank. In addition, blending and in-tank mechanical are also used for large-scale production. The blending process is essential to ensure the optimal performance and characteristics of biodiesel, making it a popular viable alternative to traditional fuels. Blending biodiesel with petroleum involves mixture of two types of fuel in specific proportions to develop a blend that meets regulatory requirements and desired performance properties. The process usually begins with the choice of petroleum-diesel fuel which is compatible with the biodiesel. The biodiesel is added to the petroleum diesel fuel, and the blend is permitted to mix very well to ensure homogeneity of the mixture. The blend ratio will depend on the desired properties of the fuel, such as emissions reduction, engine performance, and cost, and can range from as low as 2% biodiesel to 20% or even more. Blending is a popular method for bringing biodiesel to the market because it can be easily integrated into fuel framework.

6.1 MOST COMMON BLENDING METHOD

The most prevalent biodiesel blending method includes the mixing of soybean oil or other vegetable oils with petroleum-based diesel fuel in a ratio from 2% to 20% biodiesel depending on the percentage of biodiesel in the blend, and it is usually denoted as B2, B5, B10, and B20. The blending procedure is be done at a refinery or at the point of delivery, but it is significantly vital that the blend meets the ASTM6751 specifications for pure biodiesel. Blending biodiesel with petroleum-based diesel fuel aims to reduce emissions, and reliability on fossil fuels while still using existing diesel engines without modification and provide similar performance to traditional-based diesel fuel [135 – 138].

Another blending method is In-line blending which is a method of adding fuel additives and compounds to biodiesel during the production process. This process involves mixing biodiesel with the additives and compounds in a single step, resulting in a more homogeneous and consistent final product. In-line can be used to adjust the fuel properties of biodiesel, such as its cetane number, viscosity, and cold flow properties. This method is useful for large-scale biodiesel production, as it can increase efficiency and reduce costs by eliminating the need for additional processing steps. In-line also allows for greater flexibility in customizing fuel blends for specific applications and markets. As demand for sustainable fuels continues to grow, in-line is becoming an increasingly popular approach for optimizing biodiesel performance and quality [135 -138, 158]

6.3 CHALLENGES WITH BLENDING

The blending of biodiesel with petroleum diesel or other additives presents challenges primarily related to fuel and performance. The compatibility of biodiesel with other fuel components in the blend must be carefully considered, which may affect the physical properties of the fuel blend and in addition, the quality of the biodiesel feedstock may affect its properties of the final blended fuel products. During storage and transportation, biodiesel blends may undergo phase separation or microbial growth, which can reduce its efficiency or destroy fuel system components These challenges highlight the importance of an appropriate blend procedure and quality control measures to ensure consistent and reliable biodiesel blends. Another challenge in biodiesel blending is separation issues. Separation issues in biodiesel production are mainly caused by the presence of impurities and additives in the fuel. These impurities cause the fuel to separate into various layers, which can affect its overall quality and performance. Some common impurities that cause issues include water, unsaturated fatty acids, and phosphorus. Additionally, the use of certain blends or additives in the fuel can cause separation issues. For example, the use of fatty acid methyl esters (FAME), as additives may lead to instability. The separation of biodiesel can be minimized by properly pre-treating the feedstock and avoiding the use of certain impurities or additives that are known to cause issues [135 – 162].

6.4 QUALITY CONTROL

Controlling quality is essential to the manufacturing of biodiesel. It involves a strict set of guidelines and procedures to ensure that the final product meets the required standards for use as a viable fuel source. Quality assurance begins with selecting a reliable source of feedstock, which undergoes regular testing to monitor its quality and ensure it meets the necessary criteria. The production process is closely monitored at every stage, with the addition of additives and blends, to ensure that the final biodiesel produced is of the ideal level of quality. Quality control testing is conducted during and after production to ensure that the biodiesel meets all required standards. Any deviations from the necessary specifications are promptly corrected to ensure that Only premium biodiesel is offered for sale. Overall, quality control is vital to ensuring the consistent production of high-quality biodiesel that meets all necessary criteria for use as a reliable fuel source [135 – 141].

7.0 CONCLUSION

Adopting biodiesel blends offers numerous advantages that go beyond the environmental benefits of using renewable. These optimized blends offer enhanced performance and increased fuel efficiency, resulting in cost savings for users. Engine lubrication is improved, reducing wear and tear on engine parts. Furthermore, optimized blends offer higher cetane ratings than traditional petroleum diesel, which means they ignite more quickly produce less smoke and particulate matter. This is particularly important for vehicles operating in urban areas where air pollution is a major concern In addition, a host of specialized additives can be added to tailor blends for specific applications, such as cold weather formulations that improve starting. All in all, optimized biodiesel blends offer a practical and cost-effective solution for meeting our energy needs. The use of additives and blends in biodiesel has been shown to increase fuel economy. These additives and blends are designed to enhance the properties of biodiesel, making it a more efficient fuel. Increased fuel efficiency not only reduces the amount of fuel consumed but also reduces carbon dioxide emissions. Furthermore, the use of additives such as cetane improvers can help improve biodiesel performance, resulting in fuel economy. Overall, the use of additives and blends in biodiesel can have a significant impact on fuel economy, making it an efficient and environmentally friendly fuel option. To combat air pollution and meet stringent emission standards, it is crucial to reduce tail emissions from vehicles. Biodiesel, with its lower carbon content and cleaner combustion, has been found to significantly reduce emissions compared to traditional petroleum-based fuels. Additives blends of biodiesel can further enhance its emissions-reducing properties, such as reducing particulate matter, nitrogen oxide, and monoxide emissions. These additives and blends can also improve fuel economy and engine performance, making biodiesel a more sustainable and efficient choice for. Overall, the use of biodiesel and its various blends and additives can greatly contribute to reducing tailpipe emissions and improving air quality. By choosing the right additives and exploring effective blending strategies, biodiesel's performance and environmental benefits can be maximized.

8.0 REFRENCES

1. Rajkumar, S., & Thangaraja, J. (2019, March). Effect of biodiesel, biodiesel binary blends, hydrogenated biodiesel and injection parameters on NOx and soot emissions in a turbocharged diesel engine. *Fuel*, *240*, 101–118. https://doi.org/10.1016/j.fuel.2018.11.141
2. Bär, F., Hopf, H., Knorr, M., Schröder, O., & Krahl, J. (2016, September). Effect of hydrazides as fuel additives for biodiesel and biodiesel blends on NOx formation. *Fuel*, *180*, 278–283. https://doi.org/10.1016/j.fuel.2016.04.028
3. Effects of biodiesel, biodiesel blends, and a synthetic diesel on emissions from Light heavy-duty diesel vehicles. (2002, March). *Fuel and Energy Abstracts*, *43*(2), 140. https://doi.org/10.1016/s0140-6701(02)85416-9
4. Schröder, O., Bünger, J., Munack, A., Knothe, G., & Krahl, J. (2013, January). Exhaust emissions and mutagenic effects of diesel fuel, biodiesel and biodiesel blends. *Fuel*, *103*, 414–420. https://doi.org/10.1016/j.fuel.2012.08.050
5. Sivalakshmi, S., & Balusamy, T. (2013, April). Effect of biodiesel and its blends with diethyl ether on the combustion, performance and emissions from a diesel engine. *Fuel*, *106*, 106–110. https://doi.org/10.1016/j.fuel.2012.12.033
6. Omidvarborna, H., Kumar, A., & Kim, D. S. (2015, December). NOx emissions from low-temperature combustion of biodiesel made of various feedstocks and blends. *Fuel Processing Technology*, *140*, 113–118. https://doi.org/10.1016/j.fuproc.2015.08.031

7. Varatharajan, K., Cheralathan, M., & Velraj, R. (2011, August). Mitigation of NOx emissions from a jatropha biodiesel fuelled DI diesel engine using antioxidant additives. *Fuel*, *90*(8), 2721–2725. https://doi.org/10.1016/j.fuel.2011.03.047
8. Navaneeth, P., Suraj, C., Mehta, P. S., & Anand, K. (2021, June). Predicting the effect of biodiesel composition on the performance and emission of a compression ignition engine using a phenomenological model. *Fuel*, *293*, 120453. https://doi.org/10.1016/j.fuel.2021.120453
9. Bär, F., Hopf, H., Knorr, M., Schröder, O., & Krahl, J. (2016, September). Effect of hydrazides as fuel additives for biodiesel and biodiesel blends on NOx formation. *Fuel*, *180*, 278–283. https://doi.org/10.1016/j.fuel.2016.04.028
10. Najafi, G., & Shadidi, B. (2023, July 3). The influence of single and multi-carbon nanotubes as additives in diesel-biodiesel fuel blends on diesel engine combustion characteristics, performance, and emissions. *Biofuels*, 1–14. https://doi.org/10.1080/17597269.2023.2230684
11. Comparative Investigation of the Effect of Diethyl Ether and Nanoparticles as Fuel Additives in Diesel-biodiesel Blends on Performance Characteristics of Diesel Engine. (2023). *NanoWorld Journal*, *9*(S1). https://doi.org/10.17756/nwj.2023-s1-049
12. Akbarian, E., & Najafi, B. (2019, January). A novel fuel containing glycerol triacetate additive, biodiesel and diesel blends to improve dual-fuelled diesel engines performance and exhaust emissions. *Fuel*, *236*, 666–676. https://doi.org/10.1016/j.fuel.2018.08.142
13. Anwar, M., Rasul, M. G., & Ashwath, N. (2019, November). The synergistic effects of oxygenated additives on papaya biodiesel binary and ternary blends. *Fuel*, *256*, 115980. https://doi.org/10.1016/j.fuel.2019.115980
14. Kumar, D., & Singh, B. (2020, February). Effect of winterization and plant phenolic-additives on the cold-flow properties and oxidative stability of Karanja biodiesel. *Fuel*, *262*, 116631. https://doi.org/10.1016/j.fuel.2019.116631
15. Jayabal, R., Thangavelu, L., & Subramani, S. (2020, September). Combined effect of oxygenated additives, injection timing and EGR on combustion, performance and emission characteristics of a CRDi diesel engine powered by sapota biodiesel/diesel blends. *Fuel*, *276*, 118020. https://doi.org/10.1016/j.fuel.2020.118020
16. Keskin, A., Yaşar, A., Yıldızhan, A., Uludamar, E., Emen, F. M., & Külcü, N. (2018, March). Evaluation of diesel fuel-biodiesel blends with palladium and acetylferrocene-based additives in a diesel engine. *Fuel*, *216*, 349–355. https://doi.org/10.1016/j.fuel.2017.11.154
17. Lv, J., Wang, S., & Meng, B. (2022, January 29). The Effects of Nano-Additives Added to Diesel-Biodiesel Fuel Blends on Combustion and Emission Characteristics of Diesel Engine: A Review. *Energies*, *15*(3), 1032. https://doi.org/10.3390/en15031032
18. Ghanbari, M., Najafi, G., Ghobadian, B., Yusaf, T., Carlucci, A., & Kiani Deh Kiani, M. (2017, August). Performance and emission characteristics of a CI engine using nano particles additives in biodiesel-diesel blends and modeling with GP approach. *Fuel*, *202*, 699–716. https://doi.org/10.1016/j.fuel.2017.04.117
19. Kumar, N., & Raheman, H. (2022, January). Production, characterization and utilization of second-generation biodiesel blend in diesel engine using water and nanoparticles as additives. *Fuel*, *308*, 122063. https://doi.org/10.1016/j.fuel.2021.122063
20. Jaikumar, S., Srinivas, V., & Rajasekhar, M. (2021, June). Influence of dispersant added nanoparticle additives with diesel-biodiesel blend on direct injection compression ignition engine: Combustion, engine performance, and exhaust emissions approach. *Energy*, *224*, 120197. https://doi.org/10.1016/j.energy.2021.120197
21. Najafi, G., & Shadidi, B. (2023, July 3). The influence of single and multi-carbon nanotubes as additives in diesel-biodiesel fuel blends on diesel engine combustion characteristics, performance, and emissions. *Biofuels*, 1–14. https://doi.org/10.1080/17597269.2023.2230684

22. EL-Seesy, A. I., Abdel-Rahman, A. K., Bady, M., & Ookawara, S. (2016, November). The Influence of Multi-walled Carbon Nanotubes Additives into Non-edible Biodiesel-diesel Fuel Blend on Diesel Engine Performance and Emissions. *Energy Procedia*, *100*, 166–172. https://doi.org/10.1016/j.egypro.2016.10.160
23. Mujtaba, M., Kalam, M., Masjuki, H., Gul, M., Soudagar, M. E. M., Ong, H. C., Ahmed, W., Atabani, A., Razzaq, L., & Yusoff, M. (2020, November). Comparative study of nanoparticles and alcoholic fuel additives-biodiesel-diesel blend for performance and emission improvements. *Fuel*, *279*, 118434. https://doi.org/10.1016/j.fuel.2020.118434
24. Arya, M., Kumar Rout, A., & Samanta, S. (2022). A review on the effect of engine performance and emission characteristics of C.I. Engine using Diesel-Biodiesel-Additives fuel blend. *Materials Today: Proceedings*, *51*, 2224–2232. https://doi.org/10.1016/j.matpr.2021.11.359
25. Mobasheri, R., Aitouche, A., Pourtaghi Yousefdeh, S., & Zarenezhad Ashkezari, A. (2023, April 19). Assessing the Impact of Ethanol/Biodiesel/Diesel Blends and Nanoparticle Fuel Additives on Performance and Emissions in a DI Diesel Engine with EGR Integration: An Experimental Study. *Processes*, *11*(4), 1266. https://doi.org/10.3390/pr11041266
26. Ibeto, C., Ofoefule, A., & Ezeugwu, H. (2011, August 15). Fuel Quality Assessment of Biodiesel Produced from Groundnut Oil (Arachis hypogea) and its Blend with Petroleum Diesel. *American Journal of Food Technology*, *6*(9), 798–803. https://doi.org/10.3923/ajft.2011.798.803
27. Sharma, A., Pali, H. S., Kumar, M., Singh, N. K., Rahim, E. A., Singh, Y., & Gupta, N. K. (2022, October 26). Effect of α-aluminium oxide nano additives with Sal biodiesel blend as a potential alternative fuel for existing DI diesel engine. *Energy & Environment*, 0958305X2211332. https://doi.org/10.1177/0958305x221133257
28. Musthafa, B., & Asokan, M. (2024, January 2). Reducing NOx emission from palm biodiesel/diesel blends in CI engine: A comparative study of cetane improvement techniques through hydrogenation and fuel additives. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering*. https://doi.org/10.1177/09544089231223380
29. Soudagar, M. E. M., Nik-Ghazali, N. N., Abul Kalam, M., Badruddin, I., Banapurmath, N., & Akram, N. (2018, December). The effect of nano-additives in diesel-biodiesel fuel blends: A comprehensive review on stability, engine performance and emission characteristics. *Energy Conversion and Management*, *178*, 146–177. https://doi.org/10.1016/j.enconman.2018.10.019
30. Kumar, R., & Katiyar, P. (2020). Effect of Additives on Flow Properties of Different Mixture of Petroleum Diesel, Jatropha-Karanja Biodiesel Blends at Low Temperatures. *Invertis Journal of Renewable Energy*, *10*(4), 203–216. https://doi.org/10.5958/2454-7611.2020.00018.1
31. Senra, M., McCartney, S. N., & Soh, L. (2019, April). The effect of bio-derived additives on fatty acid methyl esters for improved biodiesel cold flow properties. *Fuel*, *242*, 719–727. https://doi.org/10.1016/j.fuel.2019.01.086
32. Experimental Investigation of metals and Antioxidants on Oxidation Stability and Cold flow properties of Pongamia Biodiesel and its blends. (2017). *International Journal of Renewable Energy Research*, *v7i1*. https://doi.org/10.20508/ijrer.v7i1.4913.g6962
33. Zhang, X., Li, N., Wei, Z., Dai, B., Lin, H., & Han, S. (2022). Enhanced the Effects on Improving the Cold Flow Properties and Oxidative Stability of Diesel-Biodiesel Blends by Grafting Antioxidant on Pma Type Pour Point Depressant. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4143182
34. Muniz-Wypych, A. S., da Costa, M. M., Oliveira, A. R. S., Neu, P. M., Schober, S., Mittelbach, M., Ramos, L. P., & César-Oliveira, M. A. F. (2017, October 9). Phenolic compounds obtained from alkyl oleates as additives to improve the oxidative stability of methyl rapeseed biodiesel. *European Journal of Lipid Science and Technology*, *119*(11). https://doi.org/10.1002/ejlt.201700179

35. ŞAHİN, S., & MENGEŞ, H. O. (2022, December 23). Determination of the Effects of Some Additives Added to the Mixture of Diesel and Safflower Biodiesel on Exhaust Emissions. *Tekirdağ Ziraat Fakültesi Dergisi*, *19*(4), 769–787. https://doi.org/10.33462/jotaf.1075550
36. Keskin, A., Gürü, M., & Altıparmak, D. (2007, May). Biodiesel production from tall oil with synthesized Mn and Ni based additives: Effects of the additives on fuel consumption and emissions. *Fuel*, *86*(7–8), 1139–1143. https://doi.org/10.1016/j.fuel.2006.10.021
37. İleri, E., & Koçar, G. (2014, June). Experimental investigation of the effect of antioxidant additives on NOx emissions of a diesel engine using biodiesel. *Fuel*, *125*, 44–49. https://doi.org/10.1016/j.fuel.2014.02.007
38. Rajendran, S., & Ganesan, P. (2021, February). Experimental investigations of diesel engine emissions and combustion behaviour using addition of antioxidant additives to jamun biodiesel blend. *Fuel*, *285*, 119157. https://doi.org/10.1016/j.fuel.2020.119157
39. Varatharajan, K., Cheralathan, M., & Velraj, R. (2011, August). Mitigation of NOx emissions from a jatropha biodiesel fuelled DI diesel engine using antioxidant additives. *Fuel*, *90*(8), 2721–2725. https://doi.org/10.1016/j.fuel.2011.03.047
40. Mohan, S., & Dinesha, P. (2022, July). Performance and emissions of biodiesel engine with hydrogen peroxide emulsification and cerium oxide (CeO2) nanoparticle additives. *Fuel*, *319*, 123872. https://doi.org/10.1016/j.fuel.2022.123872
41. Gaur, A., Dwivedi, G., Baredar, P., & Jain, S. (2022, August). Influence of blending additives in biodiesel on physiochemical properties, engine performance, and emission characteristics. *Fuel*, *321*, 124072. https://doi.org/10.1016/j.fuel.2022.124072
42. Kumar, N., & Raheman, H. (2022, January). Production, characterization and utilization of second-generation biodiesel blend in diesel engine using water and nanoparticles as additives. *Fuel*, *308*, 122063. https://doi.org/10.1016/j.fuel.2021.122063
43. Serrano, M., Bouaid, A., Martínez, M., & Aracil, J. (2013, November). Oxidation stability of biodiesel from different feedstocks: Influence of commercial additives and purification step. *Fuel*, *113*, 50–58. https://doi.org/10.1016/j.fuel.2013.05.078
44. Serrano, M., Martínez, M., & Aracil, J. (2013, December). Long term storage stability of biodiesel: Influence of feedstock, commercial additives and purification step. *Fuel Processing Technology*, *116*, 135–141. https://doi.org/10.1016/j.fuproc.2013.05.011
45. Murugesan, A., Avinash, A., Gunasekaran, E. J., & Murugaganesan, A. (2020, September). Multivariate analysis of nano additives on biodiesel fuelled engine characteristics. *Fuel*, *275*, 117922. https://doi.org/10.1016/j.fuel.2020.117922
46. CELIK, M., & BAYINDIRLI, C. (2022, October 27). OPTIMIZATION OF THERMOPHYSICAL PROPERTIES, COMBUSTION PERFORMANCE AND HARMFUL EXHAUST GASES OF BIODIESEL FUEL WITH NANOPARTICLE ADDITIVES. *Journal of Engineering Studies and Research*, *28*(3), 34–39. https://doi.org/10.29081/jesr.v28i3.004
47. Dodos, G. S., Tsesmeli, C. E., & Zannikos, F. (2017, December). Evaluation of the antimicrobial activity of synthetic and natural phenolic type antioxidants in biodiesel fuel. *Fuel*, *209*, 150–161. https://doi.org/10.1016/j.fuel.2017.07.039
48. Experimental Investigation of metals and Antioxidants on Oxidation Stability and Cold flow properties of Pongamia Biodiesel and its blends. (2017). *International Journal of Renewable Energy Research*, *v7i1*. https://doi.org/10.20508/ijrer.v7i1.4913.g6962
49. Sarin, A., Singh, N., Sarin, R., & Malhotra, R. (2010, December). Natural and synthetic antioxidants: Influence on the oxidative stability of biodiesel synthesized from non-edible oil. *Energy*, *35*(12), 4645–4648. https://doi.org/10.1016/j.energy.2010.09.044

50. Buosi, G. M., da Silva, E. T., Spacino, K., Silva, L. R. C., Ferreira, B. A. D., & Borsato, D. (2016, October). Oxidative stability of biodiesel from soybean oil: Comparison between synthetic and natural antioxidants. *Fuel*, *181*, 759–764. https://doi.org/10.1016/j.fuel.2016.05.056
51. Enferadi, T., Rabiei, Z., & Vannozzi, G. (2006). Protection of biodiesel based on sunflower oil from oxidative degradation by natural antioxidants. *Helia*, *29*(44), 25–32. https://doi.org/10.2298/hel0644025e
52. Chen, Y. H., & Luo, Y. M. (2011, July). Oxidation stability of biodiesel derived from free fatty acids associated with kinetics of antioxidants. *Fuel Processing Technology*, *92*(7), 1387–1393. https://doi.org/10.1016/j.fuproc.2011.03.003
53. Supriyono, Sulistyo, H., Almeida, M. F., & Dias, J. M. (2015, April). Influence of synthetic antioxidants on the oxidation stability of biodiesel produced from acid raw Jatropha curcas oil. *Fuel Processing Technology*, *132*, 133–138. https://doi.org/10.1016/j.fuproc.2014.12.003
54. Kumar, S., Kumar, R., & Kumar, M. (2018, March). RETRACTED: Experimental investigations of oxidation stability of biodiesel produced from Prunus armeniaca oil (apricot oil) and effect of various antioxidants on stability, engine performance and emissions. *Fuel*, *216*, 861–869. https://doi.org/10.1016/j.fuel.2017.11.147
55. Prabu, A. (2016, August 18). Performance and emission characteristics of a diesel engine fueled with antioxidants dispersed biodiesel and its blend with diesel. *Environmental Progress & Sustainable Energy*, *36*(2), 565–570. https://doi.org/10.1002/ep.12435
56. Rizwanul Fattah, I., Masjuki, H., Kalam, M., Hazrat, M., Masum, B., Imtenan, S., & Ashraful, A. (2014, February). Effect of antioxidants on oxidation stability of biodiesel derived from vegetable and animal-based feedstocks. *Renewable and Sustainable Energy Reviews*, *30*, 356–370. https://doi.org/10.1016/j.rser.2013.10.026
57. Jemima Romola, C., Meganaharshini, M., Rigby, S., Ganesh Moorthy, I., Shyam Kumar, R., & Karthikumar, S. (2021, July). A comprehensive review of the selection of natural and synthetic antioxidants to enhance the oxidative stability of biodiesel. *Renewable and Sustainable Energy Reviews*, *145*, 111109. https://doi.org/10.1016/j.rser.2021.111109
58. Uğuz, G., Çakmak, A., Bento, C. D. S., & Türköz Karakullukçu, N. (2022, December 28). Experimental investigation of fuel properties and engine operation with natural and synthetic antioxidants added to biodiesel. *Biofuels*, *14*(4), 405–420. https://doi.org/10.1080/17597269.2022.2156049
59. Jeyakumar, N., & Narayanasamy, B. (2020, March 31). Effect of natural antioxidants on oxidation stability of jackfruit seed oil (Artocarpus heterophyllus) biodiesel. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1–17. https://doi.org/10.1080/15567036.2020.1746442
60. Yadav, K., Kumar, N., & Chaudhary, R. (2022, January 4). Effect of synthetic and aromatic amine antioxidants on oxidation stability, performance, and emission analysis of waste cooking oil biodiesel. *Environmental Science and Pollution Research*, *29*(19), 27939–27953. https://doi.org/10.1007/s11356-021-18086-x
61. Tang, H., Wang, A., Salley, S. O., & Ng, K. Y. S. (2008, February 26). The Effect of Natural and Synthetic Antioxidants on the Oxidative Stability of Biodiesel. *Journal of the American Oil Chemists' Society*, *85*(4), 373–382. https://doi.org/10.1007/s11746-008-1208-z
62. Kalinin, P. A., Bakunin, V. N., Echin, A. I., Podkhalyuzin, A. T., & Novosartov, G. T. (1989, July). Antifoaming additives to turbine oils. *Chemistry and Technology of Fuels and Oils*, *25*(7), 348–350. https://doi.org/10.1007/bf00719336
63. Chaudhari, V. B., S.U.Patel, S., & Dhaval Sodha, D. S. (2012, June 1). Performance & Emission of C.I Engine Using Neem- Biodiesel With Additives. *International Journal of Scientific Research*, *3*(4), 164–166. https://doi.org/10.15373/22778179/apr2014/57

---

64. Bär, F., Hopf, H., Knorr, M., Schröder, O., & Krahl, J. (2016, September). Effect of hydrazides as fuel additives for biodiesel and biodiesel blends on NOx formation. *Fuel*, *180*, 278–283. https://doi.org/10.1016/j.fuel.2016.04.028
65. Han, S. S., Xu, J. Y., Zheng, G., & Sun, Y. (2011, July). A Dissertation on Polysiloxane-Antifoaming-Agents: Antifoaming Principles, Synthesis and Compound. *Advanced Materials Research*, *301–303*, 26–30. https://doi.org/10.4028/www.scientific.net/amr.301-303.26
66. ŞAHİN, S., & MENGEŞ, H. O. (2022, December 23). Determination of the Effects of Some Additives Added to the Mixture of Diesel and Safflower Biodiesel on Exhaust Emissions. *Tekirdağ Ziraat Fakültesi Dergisi*, *19*(4), 769–787. https://doi.org/10.33462/jotaf.1075550
67. Mendes, M. T., Ramalho, J. B. V. S., Karnitz Júnior, O., Palermo, L. C. M., & Mansur, C. R. E. (2019, October 8). STUDYING THE INFLUENCE OF ANTIFOAMING ADDITIVES ON CRUDE OIL/AIR INTERFACE: PROPOSAL OF A NEW METHODOLOGY. *Brazilian Journal of Petroleum and Gas*, *13*(3), 159–173. https://doi.org/10.5419/bjpg2019-0014
68. da Silva, M. J., Lopes, N. P. G., & Rodrigues, A. A. (2023, January 27). Biodiesel Additives Synthesis Using Solid Heteropolyacid Catalysts. *Energies*, *16*(3), 1332. https://doi.org/10.3390/en16031332
69. Jokubynienė, V., Slavinskas, S., & Kreivaitis, R. (2023, July 11). The Effect of Nanoparticle Additives on the Lubricity of Diesel and Biodiesel Fuels. *Lubricants*, *11*(7), 290. https://doi.org/10.3390/lubricants11070290
70. Varatharajan, K., & Pushparani, D. (2018, February). Screening of antioxidant additives for biodiesel fuels. *Renewable and Sustainable Energy Reviews*, *82*, 2017–2028. https://doi.org/10.1016/j.rser.2017.07.020
71. De Menezes, M. F. B., Freitas, R. H., Delboux, V., Duarte, V. S. P., Azevedo, W. P., & Pereira, M. A. (2022, January 6). Estudo dos efeitos dos aditivos no Biodiesel / Study of the effects of additives in Biodiesel. *Brazilian Journal of Development*, *8*(1), 937–961. https://doi.org/10.34117/bjdv8n1-061
72. Silva, P. H., Gonçalves, V. L., & Mota, C. J. (2010, August). Glycerol acetals as anti-freezing additives for biodiesel. *Bioresource Technology*, *101*(15), 6225–6229. https://doi.org/10.1016/j.biortech.2010.02.101
73. Antifoaming agent on a zeolite carrier for use in detergent powders. (1996, September). *Zeolites*, *17*(3), 317. https://doi.org/10.1016/0144-2449(96)80715-9
74. Shin-Etsu develops antifoaming agent. (2007, October). *Focus on Surfactants*, *2007*(10), 3–4. https://doi.org/10.1016/s1351-4210(07)70327-x
75. Prabu, A. (2018, April 9). Engine Characteristic Studies by Application of Antioxidants and Nanoparticles as Additives in Biodiesel Diesel Blends. *Journal of Energy Resources Technology*, *140*(8). https://doi.org/10.1115/1.4039736
76. Kumar, N., & Raheman, H. (2022, January). Production, characterization and utilization of second generation biodiesel blend in diesel engine using water and nanoparticles as additives. *Fuel*, *308*, 122063. https://doi.org/10.1016/j.fuel.2021.122063
77. Rajendran, S. (2020, April). Effect of antioxidant additives on oxides of nitrogen (NOx) emission reduction from Annona biodiesel operated diesel engine. *Renewable Energy*, *148*, 1321–1326. https://doi.org/10.1016/j.renene.2019.10.104
78. Lesniak, E., & Dul, J. (1997, November). Preparation of high-activity antifoaming silicone agents. *Polimery*, *42*(11/12), 702–705. https://doi.org/10.14314/polimery.1997.702
79. Zhan-xiong, L. (2008, December 1). Preparation, Characterization and Antifoaming Property of Fluorosilicone Oils with Fluoroalkyloxypropyl Group Substitution. *E-Polymers*, *8*(1). https://doi.org/10.1515/epoly.2008.8.1.17
80. Wang, J., Cao, L., & Han, S. (2014, January). Effect of polymeric cold flow improvers on flow properties of biodiesel from waste cooking oil. *Fuel*, *117*, 876–881. https://doi.org/10.1016/j.fuel.2013.10.006
81. 05/01071 Impact of cold flow improvers on soybean biodiesel blend. (2005, May). *Fuel and Energy Abstracts*, *46*(3), 163. https://doi.org/10.1016/s0140-6701(05)81076-8

82. Joshi, R. M., & Pegg, M. J. (2007, January). Flow properties of biodiesel fuel blends at low temperatures. *Fuel*, *86*(1–2), 143–151. https://doi.org/10.1016/j.fuel.2006.06.005
83. Fazal, M., Haseeb, A., & Masjuki, H. (2011, November). Effect of different corrosion inhibitors on the corrosion of cast iron in palm biodiesel. *Fuel Processing Technology*, *92*(11), 2154–2159. https://doi.org/10.1016/j.fuproc.2011.06.012
84. Senra, M., McCartney, S. N., & Soh, L. (2019, April). The effect of bio-derived additives on fatty acid methyl esters for improved biodiesel cold flow properties. *Fuel*, *242*, 719–727. https://doi.org/10.1016/j.fuel.2019.01.086
85. Giraldo, S. Y., Rios, L. A., & Suárez, N. (2013, June). Comparison of glycerol ketals, glycerol acetates and branched alcohol-derived fatty esters as cold-flow improvers for palm biodiesel. *Fuel*, *108*, 709–714. https://doi.org/10.1016/j.fuel.2013.02.039
86. Lv, P., Cheng, Y., Yang, L., Yuan, Z., Li, H., & Luo, W. (2013, June). Improving the low temperature flow properties of palm oil biodiesel: Addition of cold flow improver. *Fuel Processing Technology*, *110*, 61–64. https://doi.org/10.1016/j.fuproc.2012.12.014
87. Tesfaye, M., & Katiyar, V. (2016, April). Microwave assisted synthesis of biodiesel from soybean oil: Effect of poly (lactic acid)-oligomer on cold flow properties, IC engine performance and emission characteristics. *Fuel*, *170*, 107–114. https://doi.org/10.1016/j.fuel.2015.12.018
88. Pugazhendhi, A., Arvindnarayan, S., Shobana, S., Dharmaraja, J., Vadivel, M., Atabani, A., Chang, S. W., Nguyen, D. D., & Kumar, G. (2020, September). Biodiesel from Scenedesmus species: Engine performance, emission characteristics, corrosion inhibition and bioanalysis. *Fuel*, *276*, 118074. https://doi.org/10.1016/j.fuel.2020.118074
89. Kumar, R., & Katiyar, P. (2020). Effect of Additives on Flow Properties of Different Mixture of Diesel-Biodiesel- Oils and Ethanol Blends at Low Temperatures. *Invertis Journal of Renewable Energy*, *10*(4), 192–202. https://doi.org/10.5958/2454-7611.2020.00017.x
90. Khan, T. M. Y. (2021, February 6). Direct Transesterification for Biodiesel Production and Testing the Engine for Performance and Emissions Run on Biodiesel-Diesel-Nano Blends. *Nanomaterials*, *11*(2), 417. https://doi.org/10.3390/nano11020417
91. Aransiola EF. (2012, March 15). Production of biodiesel from crude neem oil feedstock and its emissions from internal combustion engines. *African Journal of Biotechnology*, *11*(22). https://doi.org/10.5897/ajb11.2301
92. Gowrishankar, S., & Krishnasamy, A. (2022, December). Novel surfactants for stable biodiesel-water emulsions to improve performance and reduce exhaust emissions of a light-duty diesel engine. *Fuel*, *330*, 125562. https://doi.org/10.1016/j.fuel.2022.125562
93. Varatharajan, K., Cheralathan, M., & Velraj, R. (2011, August). Mitigation of NOx emissions from a jatropha biodiesel fuelled DI diesel engine using antioxidant additives. *Fuel*, *90*(8), 2721–2725. https://doi.org/10.1016/j.fuel.2011.03.047
94. Roy, M. M., Wang, W., & Bujold, J. (2013, June). Biodiesel production and comparison of emissions of a DI diesel engine fueled by biodiesel–diesel and canola oil–diesel blends at high idling operations. *Applied Energy*, *106*, 198–208. https://doi.org/10.1016/j.apenergy.2013.01.057
95. Şen, M., Emiroğlu, A. O., & Keskin, A. (2018, April 6). Production of Biodiesel from Broiler Chicken Rendering Fat and Investigation of Its Effects on Combustion, Performance, and Emissions of a Diesel Engine. *Energy & Fuels*, *32*(4), 5209–5217. https://doi.org/10.1021/acs.energyfuels.8b00278
96. Mickevicius, T., Labeckas, G., & Slavinskas, S. (2022, February 1). Experimental investigation of biodiesel-n-butanol fuels blends on performance and emissions in a diesel engine. *Combustion Engines*, *188*(1), 90–95. https://doi.org/10.19206/ce-142030

97. Teoh, Y. H., How, H. G., Le, T. D., & Nguyen, H. T. (2020, September 12). Alexandrian Laurel for Biodiesel Production and its Biodiesel Blends on Performance, Emission and Combustion Characteristics in Common-Rail Diesel Engine. *Processes*, *8*(9), 1141. https://doi.org/10.3390/pr8091141
98. Atabani, A., & César, A. D. S. (2014, September). Calophyllum inophyllum L. – A prospective non-edible biodiesel feedstock. Study of biodiesel production, properties, fatty acid composition, blending and engine performance. *Renewable and Sustainable Energy Reviews*, *37*, 644–655. https://doi.org/10.1016/j.rser.2014.05.037
99. Doppalapudi, A., Azad, A., & Khan, M. (2023, March). Advanced strategies to reduce harmful nitrogen-oxide emissions from biodiesel fueled engine. *Renewable and Sustainable Energy Reviews*, *174*, 113123. https://doi.org/10.1016/j.rser.2022.113123
100. Elkelawy, M., Alm-Eldin Bastawissi, H., Esmaeil, K. K., Radwan, A. M., Panchal, H., Sadasivuni, K. K., Ponnamma, D., & Walvekar, R. (2019, November). Experimental studies on the biodiesel production parameters optimization of sunflower and soybean oil mixture and DI engine combustion, performance, and emission analysis fueled with diesel/biodiesel blends. *Fuel*, *255*, 115791. https://doi.org/10.1016/j.fuel.2019.115791
101. How, H., Masjuki, H., Kalam, M., & Teoh, Y. (2018, February). Influence of injection timing and split injection strategies on performance, emissions, and combustion characteristics of diesel engine fueled with biodiesel blended fuels. *Fuel*, *213*, 106–114. https://doi.org/10.1016/j.fuel.2017.10.102
102. Hussan, M. J., Hassan, M. H., Kalam, M. A., & Memon, L. A. (2013, July). Tailoring key fuel properties of diesel–biodiesel–ethanol blends for diesel engine. *Journal of Cleaner Production*, *51*, 118–125. https://doi.org/10.1016/j.jclepro.2013.01.023
103. Suresh, M., Jawahar, C., & Richard, A. (2018, September). A review on biodiesel production, combustion, performance, and emission characteristics of non-edible oils in variable compression ratio diesel engine using biodiesel and its blends. *Renewable and Sustainable Energy Reviews*, *92*, 38–49. https://doi.org/10.1016/j.rser.2018.04.048
104. Prakash, O., Srivastava, A. K., & Singh, B. (2022). Experimental analysis of biodiesel production from used cooking oil and its combustion, performance and emission analysis at different blending ratios in diesel engine. *International Journal of Renewable Energy Technology*, *1*(1), 1. https://doi.org/10.1504/ijret.2022.10052736
105. Lapuerta, M., Rodríguez-Fernández, J., Oliva, F., & Canoira, L. (2008, December 3). Biodiesel from Low-Grade Animal Fats: Diesel Engine Performance and Emissions. *Energy & Fuels*, *23*(1), 121–129. https://doi.org/10.1021/ef800481q
106. Katam, G. B., A., V. B., K., M. M., & Warkhade, G. S. (2017, April 10). Review on algae for biodiesel fuel production, its characteristics comparison with other and their impact on performance, combustion and emissions of diesel engine. *World Journal of Engineering*, *14*(2), 127–138. https://doi.org/10.1108/wje-06-2016-0012
107. Keskin, A., Gürü, M., & Altıparmak, D. (2007, May). Biodiesel production from tall oil with synthesized Mn and Ni based additives: Effects of the additives on fuel consumption and emissions. *Fuel*, *86*(7–8), 1139–1143. https://doi.org/10.1016/j.fuel.2006.10.021
108. Elkelawy, M., Etaiw, S. E. D. H., Bastawissi, H. A. E., Marie, H., Radwan, A. M., Dawood, M. M., & Panchal, H. (2021, June 27). WCO biodiesel production by heterogeneous catalyst and using cadmium (II)-based supramolecular coordination polymer additives to improve diesel/biodiesel fueled engine performance and emissions. *Journal of Thermal Analysis and Calorimetry*, *147*(11), 6375–6391. https://doi.org/10.1007/s10973-021-10920-1
109. Adinarayana, S., Sekhar, Y., Prakash, M. A., & Rao, B. (2011, October). Biodiesel as an Alternate Fuel in a Diesel Engine with the Cooled Exhaust Gas Recirculation–A Measure to Reduce Harmful Emissions.

International Journal of Applied Research in Mechanical Engineering, 136–141. https://doi.org/10.47893/ijarme.2011.1025

110. Rahman, M., Rasul, M., Hassan, N., & Hyde, J. (2016, May 25). Prospects of Biodiesel Production from Macadamia Oil as an Alternative Fuel for Diesel Engines. *Energies*, *9*(6), 403. https://doi.org/10.3390/en9060403
111. Hajbabaei, M., Karavalakis, G., Johnson, K. C., Guthrie, J., Mitchell, A., & Durbin, T. D. (2014, October). Impacts of biodiesel feedstock and additives on criteria emissions from a heavy-duty engine. *Fuel Processing Technology*, *126*, 402–414. https://doi.org/10.1016/j.fuproc.2014.04.030
112. Atabani, A., & César, A. D. S. (2014, September). Calophyllum inophyllum L. – A prospective non-edible biodiesel feedstock. Study of biodiesel production, properties, fatty acid composition, blending and engine performance. *Renewable and Sustainable Energy Reviews*, *37*, 644–655. https://doi.org/10.1016/j.rser.2014.05.037
113. Doppalapudi, A., Azad, A., & Khan, M. (2023, March). Advanced strategies to reduce harmful nitrogen-oxide emissions from biodiesel fueled engine. *Renewable and Sustainable Energy Reviews*, *174*, 113123. https://doi.org/10.1016/j.rser.2022.113123
114. Elkelawy, M., Alm-Eldin Bastawissi, H., Esmaeil, K. K., Radwan, A. M., Panchal, H., Sadasivuni, K. K., Ponnamma, D., & Walvekar, R. (2019, November). Experimental studies on the biodiesel production parameters optimization of sunflower and soybean oil mixture and DI engine combustion, performance, and emission analysis fueled with diesel/biodiesel blends. *Fuel*, *255*, 115791. https://doi.org/10.1016/j.fuel.2019.115791
115. How, H., Masjuki, H., Kalam, M., & Teoh, Y. (2018, February). Influence of injection timing and split injection strategies on performance, emissions, and combustion characteristics of diesel engine fueled with biodiesel blended fuels. *Fuel*, *213*, 106–114. https://doi.org/10.1016/j.fuel.2017.10.102
116. Hussan, M. J., Hassan, M. H., Kalam, M. A., & Memon, L. A. (2013, July). Tailoring key fuel properties of diesel–biodiesel–ethanol blends for diesel engine. *Journal of Cleaner Production*, *51*, 118–125. https://doi.org/10.1016/j.jclepro.2013.01.023
117. Suresh, M., Jawahar, C., & Richard, A. (2018, September). A review on biodiesel production, combustion, performance, and emission characteristics of non-edible oils in variable compression ratio diesel engine using biodiesel and its blends. *Renewable and Sustainable Energy Reviews*, *92*, 38–49. https://doi.org/10.1016/j.rser.2018.04.048
118. Prakash, O., Srivastava, A. K., & Singh, B. (2022). Experimental analysis of biodiesel production from used cooking oil and its combustion, performance and emission analysis at different blending ratios in diesel engine. *International Journal of Renewable Energy Technology*, *1*(1), 1. https://doi.org/10.1504/ijret.2022.10052736
119. Lapuerta, M., Rodríguez-Fernández, J., Oliva, F., & Canoira, L. (2008, December 3). Biodiesel from Low-Grade Animal Fats: Diesel Engine Performance and Emissions. *Energy & Fuels*, *23*(1), 121–129. https://doi.org/10.1021/ef800481q
120. Katam, G. B., A., V. B., K., M. M., & Warkhade, G. S. (2017, April 10). Review on algae for biodiesel fuel production, its characteristics comparison with other and their impact on performance, combustion and emissions of diesel engine. *World Journal of Engineering*, *14*(2), 127–138. https://doi.org/10.1108/wje-06-2016-0012
121. Keskin, A., Gürü, M., & Altıparmak, D. (2007, May). Biodiesel production from tall oil with synthesized Mn and Ni based additives: Effects of the additives on fuel consumption and emissions. *Fuel*, *86*(7–8), 1139–1143. https://doi.org/10.1016/j.fuel.2006.10.021
122. Elkelawy, M., Etaiw, S. E. D. H., Bastawissi, H. A. E., Marie, H., Radwan, A. M., Dawood, M. M., & Panchal, H. (2021, June 27). WCO biodiesel production by heterogeneous catalyst and using cadmium (II)-based supramolecular coordination polymer additives to improve diesel/biodiesel fueled engine

performance and emissions. *Journal of Thermal Analysis and Calorimetry*, *147*(11), 6375–6391. https://doi.org/10.1007/s10973-021-10920-1

123. Adinarayana, S., Sekhar, Y., Prakash, M. A., & Rao, B. (2011, October). Biodiesel as an Alternate Fuel in a Diesel Engine with the Cooled Exhaust Gas Recirculation–A Measure to Reduce Harmful Emissions. *International Journal of Applied Research in Mechanical Engineering*, 136–141. https://doi.org/10.47893/ijarme.2011.1025
124. Rahman, M., Rasul, M., Hassan, N., & Hyde, J. (2016, May 25). Prospects of Biodiesel Production from Macadamia Oil as an Alternative Fuel for Diesel Engines. *Energies*, *9*(6), 403. https://doi.org/10.3390/en9060403
125. Hajbabaei, M., Karavalakis, G., Johnson, K. C., Guthrie, J., Mitchell, A., & Durbin, T. D. (2014, October). Impacts of biodiesel feedstock and additives on criteria emissions from a heavy-duty engine. *Fuel Processing Technology*, *126*, 402–414. https://doi.org/10.1016/j.fuproc.2014.04.030
126. Vijay Kumar, M., Veeresh Babu, A., & Ravi Kumar, P. (2018, March). The impacts on combustion, performance and emissions of biodiesel by using additives in direct injection diesel engine. *Alexandria Engineering Journal*, *57*(1), 509–516. https://doi.org/10.1016/j.aej.2016.12.016
127. Tsanaktsidis, C. G. (2012, March). Using a biodegradable polymer to reduce the acidity of biodiesel and biodiesel/petroleum diesel fuel blends. *Chemistry and Technology of Fuels and Oils*, *48*(1), 44–48. https://doi.org/10.1007/s10553-012-0335-2
128. Moser, B. R. (2014, January). Impact of fatty ester composition on low temperature properties of biodiesel–petroleum diesel blends. *Fuel*, *115*, 500–506. https://doi.org/10.1016/j.fuel.2013.07.075
129. Alves, J. C. L., & Poppi, R. J. (2013). Simultaneous determination of hydrocarbon renewable diesel, biodiesel and petroleum diesel contents in diesel fuel blends using near infrared (NIR) spectroscopy and chemometrics. *The Analyst*, *138*(21), 6477. https://doi.org/10.1039/c3an00883e
130. Mirzajanzadeh, M., Tabatabaei, M., Ardjmand, M., Rashidi, A., Ghobadian, B., Barkhi, M., & Pazouki, M. (2015, January). A novel soluble nano-catalysts in diesel–biodiesel fuel blends to improve diesel engines performance and reduce exhaust emissions. *Fuel*, *139*, 374–382. https://doi.org/10.1016/j.fuel.2014.09.008
131. Behçet, R., Oktay, H., Çakmak, A., & Aydin, H. (2015, June). Comparison of exhaust emissions of biodiesel–diesel fuel blends produced from animal fats. *Renewable and Sustainable Energy Reviews*, *46*, 157–165. https://doi.org/10.1016/j.rser.2015.02.015
132. Chen, Y. H., Huang, B. Y., Chiang, T. H., & Tang, T. C. (2012, April). Fuel properties of microalgae (Chlorella protothecoides) oil biodiesel and its blends with petroleum diesel. *Fuel*, *94*, 270–273. https://doi.org/10.1016/j.fuel.2011.11.031
133. Zhang, J., He, K., Shi, X., & Zhao, Y. (2011, June). Comparison of particle emissions from an engine operating on biodiesel and petroleum diesel. *Fuel*, *90*(6), 2089–2097. https://doi.org/10.1016/j.fuel.2011.01.039
134. Magara-Gomez, K. T., Olson, M. R., Okuda, T., Walz, K. A., & Schauer, J. J. (2012, October). Sensitivity of Diesel Particulate Material Emissions and Composition to Blends of Petroleum Diesel and Biodiesel Fuel. *Aerosol Science and Technology*, *46*(10), 1109–1118. https://doi.org/10.1080/02786826.2012.696315
135. A Taguchi Method Optimization For Engine Parameters of VCR Engine Fuelled With Xanthium strumarium L. Oil Biodiesel Blend. (2022). *International Journal of Renewable Energy Research*, *Vol12i3*. https://doi.org/10.20508/ijrer.v12i3.13065.g8545
136. Mazivila, S. J. (2018, April). Trends of non-destructive analytical methods for identification of biodiesel feedstock in diesel-biodiesel blend according to European Commission Directive 2012/0288/EC and detecting diesel-biodiesel blend adulteration: A brief review. *Talanta*, *180*, 239–247. https://doi.org/10.1016/j.talanta.2017.12.057
137. Yalagudige Dharmegowda, I., Madarakallu Muniyappa, L., Suresh, A. B., Gowdru Chandrashekarappa, M. P., & Pradeep, N. (2023, April). Optimization for waste coconut and fish oil derived biodiesel with MgO

nanoparticle blend: Grey relational analysis, grey wolf optimization, driving training-based optimization and election based optimization algorithm. *Fuel*, *338*, 127249. https://doi.org/10.1016/j.fuel.2022.127249

138. Dey, P., Ray, S., & Newar, A. (2021, January). Defining a waste vegetable oil-biodiesel based diesel substitute blend fuel by response surface optimization of density and calorific value. *Fuel*, *283*, 118978. https://doi.org/10.1016/j.fuel.2020.118978
139. Subramani, S., Natarajan, K., & Lakshmi Narayana Rao, G. (2021, March). Optimization of injection timing and anti-oxidants for multiple responses of CI engine fuelled with algae biodiesel blend. *Fuel*, *287*, 119438. https://doi.org/10.1016/j.fuel.2020.119438
140. Tizvir, A., Shojaeefard, M. H., Molaeimanesh, G. R., Zahedi, A., & Labbafi, S. (2022). Optimization of Biodiesel Production from Microalgae and Analysis of Exhaust Emissions and Engine Performance for Biodiesel Blended. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4122177
141. Mondal, P., Datta, A., & Samanta, S. (2021). Techno-Economic Analysis and Multiobjective Performance Optimization of a Stationary Variable Compression Diesel Engine Fuelled with Diesel-Palm Stearin Biodiesel Blend. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3879553
142. Paparao, J., Bhopatrao, S., Murugan, S., & Kuti, O. A. (2023, March). Optimization of a low heat rejection engine run on oxy-hydrogen gas with a biodiesel-diesel blend. *Fuel Processing Technology*, *241*, 107625. https://doi.org/10.1016/j.fuproc.2022.107625
143. Adepoju, T. F. (2020, July). Optimization processes of biodiesel production from pig and neem (Azadirachta indica a.Juss) seeds blend oil using alternative catalysts from waste biomass. *Industrial Crops and Products*, *149*, 112334. https://doi.org/10.1016/j.indcrop.2020.112334
144. Lawrence, K. R., Anchupogu, P., Reddy Reddygari, M., Reddy Gangula, V., Balasubramanian, D., & Veerasamy, S. (2024, January). Optimization of biodiesel yield and performance investigations on diesel engine powered with hydrogen and acetylene gas injected with enriched Jojoba biodiesel blend. *International Journal of Hydrogen Energy*, *50*, 502–523. https://doi.org/10.1016/j.ijhydene.2023.09.166
145. Kesharvani, S., Dwivedi, G., & Nath Verma, T. (2023). Optimization of process parameter of biodiesel derived from hybrid blend of Karanja and chlorella vulgaris oil. *International Journal of Energy for a Clean Environment*. https://doi.org/10.1615/interjenercleanenv.2023047783
146. ayaraj, K., & Ganesan, A. (2018, December 25). Optimization of Injection Pressure and Injection Timing of a Diesel Engine Fuelled with Optimized Blend of B25 Cotton Seed Oil Biodiesel. *International Journal of Engineering Trends and Technology*, *66*(2), 96–102. https://doi.org/10.14445/22315381/ijett-v66p217
147. Karmakar, B., Hossain, A., Jha, B., Sagar, R., & Halder, G. (2021, February). Factorial optimization of biodiesel synthesis from castor-karanja oil blend with methanol-isopropanol mixture through acid/base doped Delonix regia heterogeneous catalysis. *Fuel*, *285*, 119197. https://doi.org/10.1016/j.fuel.2020.119197
148. Vara Lakshmi, R., Jaikumar, S., Srinivas, V., Satya Meher, R., & Lakshmi, V. (2023, July). Parametric optimization of SiO2 nanoparticle dispersed biodiesel blend with dispersant at variable loads of diesel engine using Taguchi, grey relation analysis. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2023.06.448
149. Bitire, S. O., & Jen, T. C. (2022, September). The impact of process parameters on the responses of a diesel engine running on biodiesel-diesel blend: An optimization study. *Egyptian Journal of Petroleum*, *31*(3), 11–19. https://doi.org/10.1016/j.ejpe.2022.06.004
150. Teoh, Y. H., How, H. G., Sher, F., Le, T. D., Ong, H. C., Nguyen, H. T., & Yaqoob, H. (2021, June 1). Optimization of Fuel Injection Parameters of Moringa oleifera Biodiesel-Diesel Blend for Engine-Out-Responses Improvements. *Symmetry*, *13*(6), 982. https://doi.org/10.3390/sym13060982
151. Dey, S., Reang, N. M., Majumder, A., Deb, M., & Das, P. K. (2020, July). A hybrid ANN-Fuzzy approach for optimization of engine operating parameters of a CI engine fueled with diesel-palm biodiesel-ethanol blend. *Energy*, *202*, 117813. https://doi.org/10.1016/j.energy.2020.117813

152. Bitire, S. O., & Jen, T. C. (2023, December). An optimization study on a biosynthesized nanoparticle and its effect on the performance-emission characteristics of a diesel engine fueled with parsley biodiesel blend. *Energy Reports*, *9*, 2185–2200. https://doi.org/10.1016/j.egyr.2023.01.041
153. TF, A. (2021, December 17). "Derived Biobased Catalyst from the three Agro Wastes Peel Powders for the Synthesis of Biodiesel from Luffa Cylindrical, Datura Stramonium, and Lagenaria Siceraria Oil Blend: Process Parameter Optimization." *Biomedical Journal of Scientific & Technical Research*, *40*(4). https://doi.org/10.26717/bjstr.2021.40.006483
154. Xu, H., Yin, B., Liu, S., & Jia, H. (2017, August). Performance optimization of diesel engine fueled with diesel–jatropha curcas biodiesel blend using response surface methodology. *Journal of Mechanical Science and Technology*, *31*(8), 4051–4059. https://doi.org/10.1007/s12206-017-0753-5
155. The Use of Biodiesel as a Blend Component of Commercial Diesel Fuels. (2020). *Chemistry for Sustainable Development*, *2*. https://doi.org/10.15372/csd2020211
156. Lin, C. Y. (2013, September 24). Effects of Biodiesel Blend on Marine Fuel Characteristics for Marine Vessels. *Energies*, *6*(9), 4945–4955. https://doi.org/10.3390/en6094945
157. Maksom, M. S., Nasir, N. F., Asmuin, N., Abd Rahman, M. F., & Khairulfuaad, R. (2020, April 20). Biodiesel Composition Effects on Density and Viscosity of Diesel-Biodiesel Blend: A CFD Study. *CFD Letters*, *12*(4), 100–109. https://doi.org/10.37934/cfdl.12.4.100109
158. Gaonkar, N., & Vaidya, R. G. (2015, June 7). A simple model to predict the biodiesel blend density as simultaneous function of blend percent and temperature. *Environmental Science and Pollution Research*, *23*(10), 9260–9264. https://doi.org/10.1007/s11356-015-4803-1
159. Hasan, M., & Rahman, M. (2017, July). Performance and emission characteristics of biodiesel–diesel blend and environmental and economic impacts of biodiesel production: A review. *Renewable and Sustainable Energy Reviews*, *74*, 938–948. https://doi.org/10.1016/j.rser.2017.03.045
160. Enhancement in Biodiesel Blend with the Aid of Neural Network and SAPSO. (2018, October). *Journal of Computational Mechanics, Power System and Control*, *1*(1). https://doi.org/10.46253/jcmps.v1i1.a2
161. Determination of blend level of biodiesel in petroleum diesel by 1H NMR spectroscopy. (2017, July 30). *Journal of Chemical, Biological and Physical Sciences*, *7*(3). https://doi.org/10.24214/jcbps.a.7.3.62634
162. Jiang, L., Luo, Y., & Wu, W. H. (2013, October). A Tool for Prediction of Biodiesel-Pretrodiesel Blend Ratio. *Advanced Materials Research*, *827*, 181–185. https://doi.org/10.4028/www.scientific.net/amr.827.181
163. Fathurrahman, N. A., Wibowo, C. S., Nasikin, M., & Khalil, M. (2021, July). Optimization of sorbitan monooleate and γ-Al2O3 nanoparticles as cold-flow improver in B30 biodiesel blend using response surface methodology (RSM). *Journal of Industrial and Engineering Chemistry*, *99*, 271–281. https://doi.org/10.1016/j.jiec.2021.04.037