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# To Study performance parameter on application of Undi and WCO Methyl Ester with EGR in single cylinder diesel engine

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**ABSTRACT:** Consumption of fossil fuels to meet increasing demand of globalization is increased considerably resulting in depletion of fossil fuel reserves. Stringent environmental norms and increase in greenhouse gases emissions has forced researchers to search alternatives to fossil fuels. Biodiesel (Undi and Waste Cooking oil) is one of the alternatives that can be used as fuel in conventional diesel engine without any design modifications. This project deals with synthesizing good quality of biodiesel from Undi seeds which is available cheaply in rural areas and grown in marginal lands. Different blends of Undi and waste cooking/fired oil are prepared in order to investigate the properties of blends and if necessary eco-friendly additives are added with blends. Also, it deals with validation of properties of synthesized Undi and waste cooking/fired oil Methyl ester according to ASTM 6751-96 standards.

**KEYWORDS:** ANN, Undi, WCO, Callophyllum Inophyllum, Esterification, Transesterification.

## I. INTRODUCTION

World's energy consumption has increased continuously since decade, because the world population is increasing and the economies of developing countries are expanding rapidly Present day's energy demand is increasing continuously due to the faster industrial development, increasing population and increasing the pollution due to the petroleum-based fuels. Nonedible sources like Undi, Waste cooking oil, mahua oil, Karanja oil, neem oil, jatropha oil, simarouba oil etc. are being investigated for biodiesel production. Fatty acids like stearic, palmitic, oleic, linoleic and linolenic acid are commonly found in non-edible oils. Vegetable oils blended with diesel in various proportions have been experimentally tested by a number of researchers in several countries.

To fulfill this energy demand and to control the pollution by using alternative fuel. The alternative fuels like biodiesel production. Vegetable oil are high fatty acid with high viscosity compare to the pure diesel fuel, so it is need to reduce the free fatty acid level and viscosity of vegetable oil. Excessive use of the fossil fuels has led to global environmental degradation and health hazards. The increasing concern of environmental protection and more stringent regulation on exhaust emissions, reduction in engine emissions becomes a major task in engine development. In addition to this lots of efforts are needed to reduce dependence on the petroleum fuels as it is obtained from limited reserves. These concerns led research on alternative renewable. Among the proposed alternative fuels biodiesel and ethanol have received much attention in recent years for diesel engines.

Biodiesel is typically made by chemically reacting lipids e.g., vegetable oil, soybean oil, animal fat with an alcohol producing fatty acid esters. Globally, the awareness of energy issues and environmental problems associated with burning fossil fuels has encouraged many researchers to investigate the possibility of using alternative sources of energy instead of oil and its derivatives.

## II. LITERATURE REVIEW

Availability and economic aspects are first considered when selecting biodiesel. The characteristics of engine performance are then considered, indicating the applicability of the biodiesel in engines. Brake power, brake torque, brake thermal efficiency (BTE), and brake specific fuel consumption (BSFC) are the performance indicators. Factors such as air–fuel mixture, fuel injection pressure, fuel spray pattern, and fuel properties affect performance. These parameters are tested against engine load or engine speed in the literature review. Engine performance characteristics of the reviewed biodiesel are discussed below.

[1] In the paper of Charudatta M. Kshirsagar, RamanathanAnand, ‘Artificial neural network applied forecast on a parametric study of Calophyllum inophyllum methyl ester-diesel engine out responses’ in 2017 states that the success of any model depends upon a clear understanding of the problem under consideration and identification of the vital process control variables to be modeled, in this work, separate ANN models for performance and emission variables were used to predict the relationship of BTE, BSEC, EGT, CO, CO<sub>2</sub>, UBHC, NO, dry soot and engine out O<sub>2</sub> with percentage load, blending percentage, FIP FIT as the input variables. Twenty percentage blend of the biodiesel in neat diesel showed the highest BTE among the CIME-diesel blends at 300 bar fuel injection pressure at rated fuel injection timing. The outcomes of these proposed ANN models have been examined on a wide statistical level of error and performance matrix in relation with the target data with its applicability limited to the engine under consideration.

[2] Fan Fangfangag, AvinashAlagumalaib, Omid Mahian, with titled ‘Sustainable biodiesel production from waste cooking oil: ANN modeling and environmental factor assessment’ the review states that , this study was conducted to access the environmental impact of waste cooking oil biodiesel production and application of artificial neural networks to predict the biodiesel yield and its engine characteristics. Waste cooking oil was used as feedstock for biodiesel production. The experiment followed the control variable method. The four variables controlled by the experiment are catalyst %, molar ratio, reaction time, mixing intensity (rpm). The developed ANN model can predict waste cooking oil biodiesel yield and engine characteristics, which has been proved by high R value. . However, it should be noted that a drawback of transesterification with an alkaline catalyst is the process sensibility to the reagent purity, particularly in water and free fatty acid contents. Thus, the model prediction would change if the condition is changed during the alkaline transesterification.

[3] Babu D, VinothThangarasu, AnandRamanathan, with name of paper ‘Artificial neural network approach on forecasting diesel engine characteristics fuelled with waste frying oil biodiesel’ In this work, biodiesel is synthesized from waste frying oil feedstock procured from Tiruchirappalli, Tamil Nadu, India. The transesterification reaction was performed at a molar ratio of 1:6 of oil to alcohol, the temperature of 55 °C, catalyst loading of 1.5 wt%, the reaction time of 150 min and a stirrer speed of 975 rpm achieved the maximum yield of 97.4%. Synthesized raw biodiesel was purified with the help of distilled water to remove excess catalyst and methanol. The back-propagation multilayer perceptron feed-forward neural network (BPNN) is used for prediction in engineering applications. The experimental results exhibited that biodiesel fuel produced minimum exhaust emission both in advanced and retarded injection timing as related to conventional diesel. An advanced injection strategy is suggested for higher viscosity fuel to ensure better engine characteristics.

[4] In the paper of Joseba Castresanaa, Gorka Gabinaa, Leopoldo Martinb, ZigorUriondo, ‘Comparative performance and emissions assessments of a single-cylinder diesel engine using artificial neural network and thermodynamic simulation’ states that two prediction tools were compared when facing different engine loads and operating points. Both tools, such as, the thermodynamic and artificial intelligence models, were fitted to predict BSFC, Texh, CO and NO<sub>x</sub> based on engine speed and BMEP. Both models are capable of accurately predicting engine performance parameters (MAPE below 6 in BSFC and below 2% in Texh). ANN shows better results than the thermodynamic model for BSFC prediction, regardless of engine load. The thermodynamic model’s prediction of Texh is more accurate than the ANN prediction for medium–low loads, while ANN performs better with higher loads. The time consumed for calculations is much higher in the thermodynamic model than in the ANN model. Neural Networks have proved to be an effective tool for diesel engine performance prediction and fault detection.

[5] L.Saravanakumara,R.Prakash, in the paper named ‘Validation of performance and emissions of a CI engine fueled with calophylluminophyllum ethyl esters using soft computing technique’, has been carried out an experiment using Calophylluminophyllum methyl esters on diesel engine with different proportions of biodiesel blends at different loads. A soft computing model was developed using ANFIS with the different outputs obtained from the experiment. The validated outputs were evaluated on a statistical platform of error and compared with the measured outcomes. A consistent nearness of the validated outputs with measured results was detected and the error was minimized using ANFIS. The good performance of ANFIS on comparison with the experimental work was seen. Using ANFIS, more than 90% accuracy were seen for all the performance and emission parameters.



[6] In the paper of Raif Kenanoglu, Mustafa Kaan Baltacioglu and et al with title 'Performance and emission analysis of NHO enriched dual fuelled diesel engine with artificial neural network prediction method' carried the work with basic fiction of reducing diesel fuel dependency by using soyabean oil biodiesel. Two types of liquid test fuels have used in this study, which are euro diesel and soyabean oil methyl ester. Experiment comes out with conclusion that, various amount of NHO enrichments to soyabean biodiesel blend fuel can be used in CI engines without any engine modification. Besides, experiments showed that the NHO enrichment increased brake torque and power outputs with direct correlation to flow rate amount; at same time brake specific fuel consumption has decreased. Unfortunately, NOx emission has increased during the performance improvement. The result shows that the ANN model has 95.82%, 96.07%, and 92.35% estimation accuracies for motor torque, motor power, and NOx emission respectively.

[7] S. Raghuvaran, B. Ashok and et al in the article 'Evaluation of performance and exhaust emission of CI diesel engine fuel with palm oil biodiesel using an artificial neural network' they studied the engine exhaust emission and engine performance parameters by using ANN by considering various model configuration. Back- progression algorithm is utilized in developing ANN models. The biodiesel blends used during experimental study was of palm oil. It is observed that the BFSC decreases sharply for all blends of fuel with increase in loading. It can be concluded that, the brake power, BFSC, BTE, CO, NOx, and HC emissions predicted by Artificial neural network model is accurate, fast and reliable.

[8] In the article 'Artificial Neural Network based prediction of a direct injected diesel Engine performance and emission characteristics powered with biodiesel' by Karthikeyan Subramanian, A.P. Sathiyagnanam, and et al carried experiment the engine examine were performed with perfect biodiesel on a diesel engine and its diesel blends (10%, 20%, 30%, 50% & 100% (%v/v)) to decide the engine performance and emissions in contrast with using diesel. In this analysis, ANN model was developed to simulate the relationship between BTE and exhaust emissions, such as CO, HC, smoke, and NOx of a DI CI engine fueled biodiesel-diesel mixtures and loads as input data. Increase in emission of NOx for higher blend ratio was observed. The analysis of the exploratory data by the ANN showed a good relationship between the results of the ANN and the exploratory results. Right now, ANN is a very useful tool for predicting the performance of engine and emission parameters. They states that ANN models might be utilized as an elective route in engineering analysis and forecasts.

[9] B. Ghobadian, H. Rahimi, and et al in the article named Diesel engine performance and exhaust emission analysis using waste cooking biodiesel fuel with an artificial neural network' studied Biodiesel is a safe, non-toxic, biodegradable and renewable fuel that can be easily used in unmodified diesel engine, and a variety of other applications. The viscosity of waste vegetable oil is very high to be directly used as diesel fuel substitute. Transesterification of the waste vegetable oil reduced the viscosity from 31.8 mm<sup>2</sup>/s to 4.15mm<sup>2</sup>/s. biodiesel was produced from waste vegetable cooking oil of a restaurant. The ANN approach has been applied to predict the performance of various thermal systems. An ANN model for the diesel engine with diesel and biodiesel blended fuels was developed using the data gathered in test runs. In the model, 80% of the data set was randomly assigned as the training set, while the remaining 20% of data are put aside for prediction and validation. A network with one hidden layer and 25 neurons proved to be an optimum ANN. Generally speaking, ANN provided accuracy and simplicity in the analysis of the diesel engine performance under test.

[10] In the paper of Omer B'oyükdipia, G.okhanTüccara, Hakan Serhad Soyhan, 'Experimental investigation and artificial neural networks (ANNs) based prediction of engine vibration of a diesel engine fueled with sunflower biodiesel – NH<sub>3</sub> mixtures' in 2021 states that an ANN can be defined as a system that simulates the functioning of nerve conduction in the human brain. Three layers provide information flow in the scope of ANN. These layers are input, hidden, and output layers. ANN is an important part of the study in terms of validating vibration data. In this study, sunflower biodiesel was produced from vegetable oil and NH<sub>3</sub> was used as a fuel additive at different proportions (5%, 10%, and 15%). The experiments were conducted by using the Mitsubishi Canter 4D31 diesel engine. The vibration data were recorded during the engine experiments by using accelerometer sensor. Moreover, ANN model was generated to predict the vibration data in the varying the engine speed. All experimental data and ANN model data were compared with each other to observe the effect of NH<sub>3</sub> additive on engine vibration. As a result of the generation of the ANN model, a formulation was created to estimate the engine vibration parameter based on unrelated parameters between each other. Besides, time and experimental costs were saved.

[11] Sundararajan Rajkumar, Arnab Das, Jeyaseelan Thangaraja in the article 'Integration of artificial neural network, multi-objective genetic algorithm and phenomenological combustion modeling for effective operation of biodiesel blends in an automotive engine' studied the ANN model predicted the engine output parameters with low values of mean square error, mean square relative error, mean absolute percentage error and standard error of prediction. The engine experiments are conducted with diesel and diesel-biodiesel blends namely jatropa, and karanja consisting of 120 data points each. This set of data is used for the ANN development and validation. In this work, a novel approach is suggested for modeling the engine performance, combustion and emission parameters adopting dynamic and robust

prediction models such as ANN, MOGA, and multi-zone phenomenological models. This integrated modelling approach can be a useful tool for model-based control of bio fuelled engines.

[12] Anh Tuan Hoanga, Sandro Nizetic, and et al in the paper named 'A review on application of artificial neural network (ANN) for performance and emission characteristics of diesel engine fueled with biodiesel-based fuels' studied on ANN-based prediction of engine behaviour fueled with biodiesel. For ANN application in diesel engines, ANN was applied widely to identify a number of engine operating factors fueled by biodiesel and its blending. In general, findings from this current work could show the critical role of the ANN model in the optimization of the engine performance and emission characteristics fueled with biodiesel-based fuels. Throughout this review, there has been a strong consensus on the important role of applying artificial intelligence methods in predicting diesel engine performance and emissions.

[13] Muhammad Fadhlullah, Sri Nanan B, Widiyanto, Elvi Restiawaty, 'The potential of nyamplung (*Calophyllum inophyllum* L.) seed oil as biodiesel feedstock: effect of seed moisture content and particle size on oil yield' *Calophyllum inophyllum* is one of the most potential plants for biodiesel feedstock because of its high oil content. *C. inophyllum* oil obtained under the experimental conditions has characteristics that support its utilization as biodiesel feedstock. These results can also serve as a practical reference to local farmers and bio-oil producers. To better help the local communities, a further research could be carried out to investigate the effects of wider climate conditions of the Cipatujah region on the production of *C. inophyllum* oil.

[14] A.E. Atabani, Aldara da Silva César, 'Calophyllum inophyllum L. – A prospective non-edible biodiesel feedstock. Study of biodiesel production, properties, fatty acid composition, and blending and engine performance' The main objective of the present paper is to investigate the potential of *Calophyllum inophyllum* as a promising feedstock for biodiesel production. In this paper, several aspects such as physical and chemical properties of crude *Calophyllum inophyllum* oil, Crude *Calophyllum inophyllum* oil was reported to be highly acidic. Therefore, a two-step of acid–base catalysed transesterification process was used to produce biodiesel from this feedstock, Blending of CIME with diesel and other biodiesel feedstock resulted in a remarkable improvement in some physical and chemical properties

[15] S.G.Bhat,J.G.KaneA.Sreenivasan, 'The in Vitro Evaluation of the Antibacterial Activity of Undi Oil (*Calophyllum inophyllum* Linn.) Three samples of Undi oil obtained by crushing in ghanis, rendering, and solvent extraction, respectively', The antibacterial activity of Undi oil was tested by the agar streak assay against some pathogenic and nonpathogenic organisms, of both Grampositive and Gram-negative types, The curves were extrapolated to the diameter of the agar cup, as the zones of inhibition were not clear beyond a certain concentration. Transfers made from the zones of inhibition into tubes containing nutrient broth showed no growth when incubated overnight, indicating that the action was also bactericidal.

[16]Mohit Jain, Usha Chandrakant, Valérie Orsat, Vijaya Raghavan, 'A review on assessment of biodiesel production methodologies from *Calophyllum inophyllum* seed oil' Fossil fuels have been considered as one of the most important sources of energy. Today, people are widely using fossil fuels as an energy source to carry out their basic activities like transportation, cooking, and agriculture, There has been a significant increase in the research in biodiesel production from *C. inophyllum* seed oil in the last few years. Researchers all over the world have started exploring the untapped potential of *C. inophyllum* seed oil as a valuable feedstock for biodiesel production in the future. Going forward, to improve the efficacy of the fuel usage, one can look into optimizing the efficiency of the combustion engine fuelled with higher blends of biodiesel and diesel fuel, alongside look for.

[17] Adeniyi Abiodun, AdenugaJohn, Adekunle Oyedele, Oyekunle, 'Pathway to reduce free fatty acid formation in *Calophyllum inophyllum* kernel oil: A renewable feedstock for biodiesel production', The study presented a proposed method to improve the qualities of biodiesel produced from the oil extracted from *Calophyllum inophyllum* kernel. This study has demonstrated that the condition under which *Calophyllum inophyllum* kernels were dried played a major role in the quantity and quality of the biodiesel derived from the kernels. The variations in the drying conditions resulted in a reduced level of free fatty acids in the oil by as much as 69% without any cumbersome chemical processes and resulted in more than 10% improvement in the quantity of the biodiesel produced. Important parameters that have been established to play significant roles in the quality of oil and biodiesel were found at satisfactory level in the produced biodiesel.

[18] R.Sakthivel, K. Ramesh P, Mohamed Shameer, 'Experimental investigation on improvement of storage stability of bio-oil derived from intermediate pyrolysis of *Calophyllum inophyllum* seed cake' Bio-oil samples were analysed for elemental carbon, hydrogen, nitrogen, sulphur and oxygen composition using Perkin Elmer 2400 Series II CHNSO elemental analyzer following protocols formulated by ASTM D5291-96. In the ultimate analysis of samples C, H, N, S and O were determined on a dry basis. The kinematic viscosity of the obtained bio-oil samples was determined by using Simple VIS automated kinematic viscometer. The method used is ASTM D445 for determining the viscosity of samples before and after the accelerated aging procedure at 40 C.

- [19] M.I.JahirulJ, R.Brown, W.Senadeera., 'Optimisation of Bio-Oil Extraction Process from Beauty Leaf (Calophyllum inophyllum) Oil Seed as a Second Generation Biodiesel Source', Seed processing, drying and oil extraction methods a significant impact on oil yields and the success of Beauty Leaf as future generation biodiesel feedstock. Drying the seed kernel to optimum moisture content was found to be crucial to the success of both mechanical extraction and hexane extraction. Kernels prepared with 15% moisture content provided the highest oil yields for both extraction methods. Mechanical extraction using the screw press is ineffective, with relatively low yields for a great deal of effort. Chemical extraction using hexane as a solvent was found to be very effective, however due to a limited supply of hexane and the lack of a hexane recovery system, it was not possible to take full advantage of the effectiveness of the method. Therefore it is recommended to use chemical oil extraction with hexane recovery system to reduce the production cost of Beauty Leaf biodiesel.
- [20] NurAfiqah, Fauzan Ee, Sann Tan, 'Physiochemical properties evaluation of Calophyllum inophyllum biodiesel for gas turbine application' Environmental pollution and depletion of fossil fuels have encouraged the search for replacement of fossil fuel consumption. Emission of hazardous gases such as volatile organic compounds (VOC), carbon dioxide (CO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>), and hydrocarbons (HC) are the consequences from combustion of fossil fuel. The demand for fossil fuels and the increase of greenhouse gas (GHG) emissions are causing detrimental damages to our climate system. Hence, it is necessary to identify the fuel composition and the supply condition to prevent any constituent of the fuel contaminant on the gas turbine operation C. inophyllum biodiesel compared with ASTM D2880 Standard Specification of Gas Turbine Fuel Oil and ASTM D6751 Standard Specification for Biodiesel Fuel Blend Stock.
- [21] Muhammad Fadhlullah Sri, B. Widiyanto Elvi Restiawaty, 'The Potential of Nyamplung (Calophyllum inophyllum) Seed Oil as Biodiesel Feedstock: Effect of Seed Moisture Content and Particle Size on Oil Yield' Here the decrease of fossil fuel deposit and negative impacts of its utilization on environment has increased the alternative fuel development, including biodiesel. Biodiesel is a renewable, environment friendly and non-toxic fuel. It does not contain sulphurous and aromatic compounds, C. inophyllum oil obtained under the experimental conditions has characteristics that supports its utilization as biodiesel feedstock. These results can also serve as a practical reference to local farmers and bio-oil producers. To better help the local communities, a further research could be carried out to investigate the effects of wider climate conditions of the Cipatujah region on the production of C. inophyllum oil.
- [22] In the paper of Niraj B Dole & Rahul B Barjibhe 'Character traits of Hybrid Bio-Fuel as performance and exhaust emissions in a Diesel Engine' 2022 states that the research aims to use non-edible oil seeds that are cheap in rural areas and grown on poor soil. To evaluate the quality of blends, numerous blends of Undi and residual cooking/fired oil are prepared, and if necessary, eco-friendly additives are applied to the blends. Also, it works with the testing of the qualities of synthesised undi as well as waste cooking or firing oil in a single cylinder, four-stroke diesel engine, Undi oil biodiesel blends were used, and the results were compared to diesel fuel.
- [23] R.SusanthKishna, M.Pranava Kumar, PathikritBhowmick, 'Investigation on pilot injection with low temperature combustion of Calophyllum inophyllum biodiesel fuel in common rail direct injection diesel engine', In the present study, the performance, combustion and emission characteristics of 20% blend of CIME is analysed for different pilot injection quantities and EGR rates. The foremost objective of this research was to identify the limiting values of both pilot injection quantity and EGR rates for which both the strategies can be incorporated at the same time without sacrificing performance for curbing emissions. For all the fuel samples, the fuel injection pressure is kept constant at 600 bar, while the pilot injection quantity is varied from 5% to 15% and EGR for 10%, 20%
- [24] In the paper of Zhang, Y., Dubé, M.A., McLean, D.D., title as Kates, Waste oil derived biofuels in China bring brightness for global GHG mitigation This study proposed a novel way for global greenhouse gas reduction through reusing China's waste oil to produce biofuels. This study constructed the inventory of waste oil and analysed biofuel potential and relevant environmental benefits. Life cycle GHG mitigation potential of aviation bio-kerosene and biodiesel derived from China's waste oil in 2010 was equivalent to approximately 28.8% and 14.7% of mitigation achievements on fossil-based CO<sub>2</sub> emissions by Annex B countries of the Kyoto Protocol in the period of 1990–2008, respectively. China's potential of producing biodiesel from waste oil in 2010 was equivalent to approximately 7.4% of China's fossil-based diesel usage.
- [25] Daniel P. Geller, Thomas T. Adams, John W. Goodrum, Joshua Pendergrass, title as Optimization of Continuous Biodiesel Production from Rubber Seed Oil (RSO) using Calcined Eggshells as Heterogeneous Catalyst. The present study illustrates about the continuous biodiesel production from rubber seed oil (RSO) as feedstock using calcium oxide (CaO) derived from eggshells as heterogeneous catalyst. The feedstock RSO was procured from virudhunagar, Tamilnadu is of commercial grade, Methanol used for this study is analytical grade supplied by CDH suppliers, New Delhi, India, and sulphuric Acid used for pre-treatment process (98% concentration, EMPARTA) Is analytical grade

supplied by Merck life sciences private limited, Mumbai. Continuous biodiesel production from RSO using calcined eggshells as heterogeneous catalyst .Has been studied. Optimization of process parameters which influence the RSO conversion to Biodiesel using two different models namely response surface methodology (RSM) and artificial Neural network (ANN) is also studied

### III. CRITICAL LITERATURE REVIEW

- Engine performance and emission characteristics fueled with biodiesel were studied and analysed using ANN (Artificial Neural Network ) application by various researchers . they have used different biodiesel blends made by using calophyllum Inophyllum , WCO(waste cooking oil),euro diesel,soyabean oil, palm oil, sunflower, jatropha and karanja etc with ANN and concluded that ANN model accuracy was up to the expectations. time consumed for calculation in ANN is less than other thermodynamic models . ANN model might be utilized as an elective route in engineering forecast and analysis. Also the model prediction would change if the condition is changed during transesterification. (1,2,3,4,6,7,8,9,10,11,12,25)
- Production methodologies, properties of biodiesel using Undi Callophyllum Inophyllum were explained and optimization is done by various researchers. Many researchers used Undi in preparation and analysis of biodiesel and introduced methodologies which included Extraction process, Esterification, Transesterification etc. Researchers over the world have started exploring the potential of Undi based biodiesel. Undi Callophyllum Inophyllum possesses emission and performance characteristics.(5,13,14,15,16,17,18,19,22,23)
- Many researchers claimed the Environmental pollution and depletion of fossil fuels tends to study the replaceable biodiesel. They explained the emission of hazardous gases using fossil fuel i.e. CO<sub>2</sub> , NOx, HC, etc. and said that Biodiesel is a renewable, environment friendly and non-toxic fuel.(20,21,24)

### IV. CONCLUSIONS

From the detailed discussion on literature review we come to conclusion that the use of Undi Callophyllum Inophyllum has been studied the emission and performance characteristics of biodiesel made using Undi are satisfactory. The ANN optimization technique is reliable and increases the accuracy. ANN model might be utilized as an elective route in engineering forecast and analysis.

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