International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Review Article)

Check for updates

Electrical properties evaluation of corn oil biodiesel mixed with lubricant as a potential source of energy

Raviteja Surakasi [1,*], Janaki Pakalapati [2], Manyala Gangadhar Rao [1] and B. Ushaswini [1]

[1] *Department of Mechanical engineering, Lendi institute of engineering and technology, Jonnada, Vizianagaram, Andhra pradesh, India.*

[2] *Department of Electrical and Electronics engineering, Lendi institute of engineering and technology, Jonnada, Vizianagaram, Andhra pradesh, India.*

International Journal of Science and Research Archive, 2024, 11(02), 2108–2116

Publication history: Received on 17 March 2024; revised on 26 April 2024; accepted on 29 April 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.11.2.0743

Abstract

The main aim of this study is to assess the electrical characteristics pertaining to a biodiesel derived from corn oil and lubricant. The first step in the synthesis of biodiesel from corn oil involves the transesterification process. Subsequently, the biodiesel is combined with a base lubricant (20W-40T) in varying proportions, spanning from 5% to 40% of the overall volume. The measurement and analysis of biodiesel blends necessitate consideration of crucial electrical parameters, including breakdown voltage, resistivity, permittivity and electrical conductivity. The decrease in breakdown voltage, permittivity, and electrical conductivity that ensues from an increase in diameter may be attributed to the corresponding increase in diameter. Nevertheless, a positive association exists between the greater quantity of base lubricant and an elevation in resistivity. Despite the positive correlation between resistivity and diameter, this phenomenon persists. The potential cause for the enhancement of the electrical properties might be attributed to the dispersion of the fundamental lubricant.

Keywords: Breakdown voltage; Permittivity; Resistivity; Electrical conductivity

1. Introduction

Over the past few years, there seems to be a developing interest in corn oil biodiesel as a renewable fuel option, which is increasingly being seen as a viable alternative to conventional fossil fuels. This shift in attention may be attributed to the environmental advantages associated with the use of corn oil biodiesel [1-6]. However, biodiesel is subject to many restrictions, such as insufficient cold flow properties, decreased oxidative stability, and poor electrical conductivity [7-9]. The possible influence of reduced electrical conductivity in biodiesel on fuel injection as well as ignition systems could lead to unfinished combustion including a subsequent drop in engine performance [10-12]. In order to mitigate this constraint, scholars have undertaken investigations on the use of lubricants as additives with the aim of enhancing the electrical characteristics of biodiesel. The utilization of 20W-40T base lubricant as additives has been explored in light of their notable electrical conductivity and substantial surface area, as documented in previous studies [13-18]. In the present study [14] the impact of the base lubricant on the electrical characteristics of maize oil biodiesel has been examined. The intent of this study is to examine the electrical conductivity as well as dielectric strength associated with the fuel, both with and without the use of lubricating additives [15]. The present work aims to conduct a comprehensive investigation of the influence of nanoparticle amount and dimension on the electrical properties of the fuel. This study has significant relevance for both the biodiesel sector and academics engaged in the advancement of energy systems that are more efficient and sustainable. The results of this research have the potential to facilitate the advancement of novel and enhanced biodiesel fuels that exhibit superior electrical characteristics. Consequently, this might facilitate the broader integration and use of such fuels across diverse industrial sectors.

* Corresponding author: Raviteja Surakasi

2. Preparation of Biodiesel Samples

Fig 1 explains about the biodiesel preparation process. Fig 3 shows the flow chart of biodiesel preparation

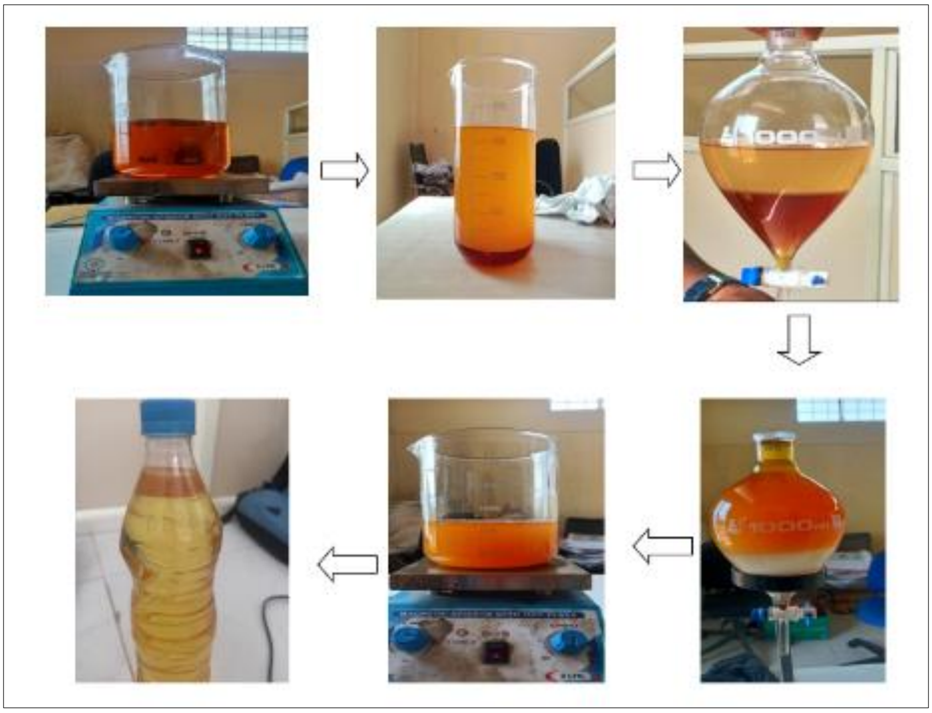

Figure 1 Biodiesel preparation process

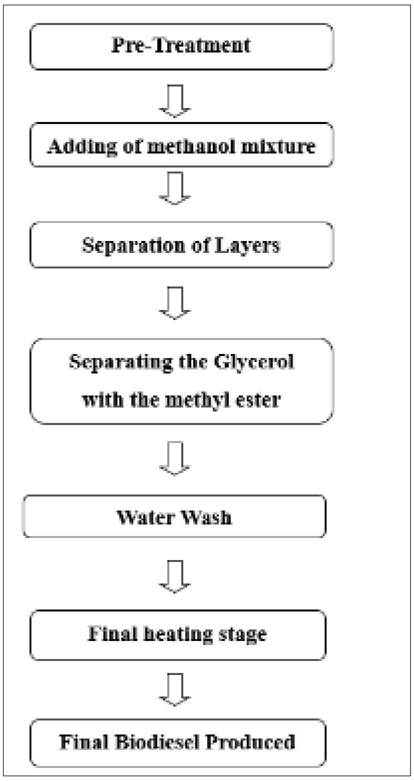

Figure 2 Flow chart of biodiesel preparation

The 1200 ml of Corn oil is subjected to a temperature about 40˚C by the utilization of a Magnetic Stirrer or Mixer. Following this, the experimental procedure involves the amalgamation of 3.5 grams of sodium hydroxide (KOH) pellets mixed 125 milliliters of methanol. It is advisable to lower the temperature once the oil has reached a temperature range of 56 degrees Celsius to 58 degrees Celsius. Permit the oil to undergo a period of one hour of rest. The oil should be let to undergo separation, so facilitating the settling of the fatty acids and glycerol [16]. Subsequently, use a separating funnel as a means to separate the glycerol component from the oil. Following this, the oil undergoes a comprehensive washing procedure with either distilled water or heated water. Following this, the obtained oil should be subjected to an extra warming procedure with a Magnetic Stirrer, therefore elevating the temperature to 90 ˚C. The purpose of this step is to enhance the evaporation process of any water bubbles that could be present inside the oil. The collection and storage of oil should be carried out in specifically designed containers, which should be followed by an additional processing phase that involves the mixing of the oil [17].

2.1. Fuel Blending

The first step in the biodiesel blending process is the establishment of the desired blend ratio. In general, the proportion of biodiesel to petroleum diesel is often represented as a numerical percentage. After the appropriate blend ratio is established, Biodiesel is then mixed with varying volumes of 20W-40T base lubricant, ranging from 5% to 40%, using an Ultrasonicator equipment [18]. The biodiesel-blended lubricant that has been developed is utilized for the purpose of analyzing breakdown voltage, dielectric constant, electrical conductivity, and resistivity. A total of 9 samples were prepared using corn oil biodiesel and base lubricant by varying the percentage of lubricant from 5% to 40%

3. Materials and Methodology

3.1. Base Lubricant (20W-40T)

Figure 3 20W-40 lubricant

20W-40 lubricant is a type of engine oil that is commonly used in a variety of vehicles, including motorcycles, cars, and trucks which is shown in fig 2. The "20W" in its name indicates the oil's viscosity rating for cold temperatures, while the "40" refers to its viscosity rating for high temperatures. This type of lubricant is designed to provide excellent protection for engines in a wide range of operating conditions, including high-speed and high-temperature environments. It is formulated with a combination of base oils and additives that work together to reduce engine wear, improve fuel efficiency, and extend the life of the engine. Overall, 20W-40 lubricant is a reliable choice for ensuring optimal engine performance and longevity [19].

3.2. Breakdown voltage

The term "breakdown voltage" is often used when referring to the minimum voltage necessary to induce electrical conduction inside a material. This term describes the minimal voltage required to produce electrical conduction. This indicates that there is a particular voltage at which the electrical resistance of the material reduces dramatically, making it possible for current to flow through it.

The occurrence of breakdown voltage might manifest in several ways, contingent upon the specific material and prevailing circumstances. Several prevalent forms of breakdown voltage include:

- Diodes with highly doped p-n junctions are prone to Zener breakdown. The Zener voltage is the reverse bias voltage above the junction above which the junction opens to enable current to flow in the exact opposite direction.
- Avalanche breakdown is a phenomenon seen in some materials, particularly semiconductors, when the application of a strong electric field results in the acquisition of sufficient kinetic energy by free electrons to dislodge more electrons. This initiates a cascading reaction, ultimately leading to the generation of a substantial electric current.
- When the electric field intensity exceeds a certain threshold, atoms and molecules within an insulating material become ionized, a process known as dielectric breakdown. This creates a channel for electrical current.

The determination of the breakdown voltage of a substance has significant importance in several electrical applications, and its value may be influenced by various variables including temperature, humidity, and the existence of impurities or faults within the substance.

3.3. Dielectric constant

The dielectric constant, which is also called the relative permittivity, is a way to measure how much electrical energy an object can store in an electric field. A material's internal electric flux density divided by its external electric flux density provides the relevant dimensionless number.

The dielectric constant measures how much an external electric field polarizes a material. Materials possessing a dielectric constant that is high have the capacity to accumulate a substantial amount of electrical energy within an electric field, yet materials characterized by a dielectric constant that is low exhibit a diminished ability to store such energy.

Electrical applications use the dielectric constant. In capacitor manufacture, it stores energy in an electric field. To store more energy, capacitors employ materials with a very high dielectric constant.

The dielectric constant is influenced by temperature, pressure, and frequency. As a material's dielectric constant decreases with temperature, its electrical components may work poorly.

3.4. Electrical Conductivity

Electrical conductivity, denoted by the symbol σ, represents the quantitative assessment of a material's capacity to facilitate the flow of electrical current. A conductor refers to a substance that exhibits minimal resistance to the passage of electric current or heat energy. Materials can be categorized into three main groups: metals, semiconductors, and insulators. The electrical conductivity of materials is a crucial characteristic in electronic applications. The utilization of mathematical models to estimate electrical conductivity presents an economically viable approach for assessing the electrical conductivity of materials composed of two or more constituents. There are various methodologies for the modeling of electrical conductivity in composites, which can be broadly classified into three main categories: simulation approaches, analytical-mathematical methods, and image processing methods. The units of conductivity are expressed as Siemens per meter (S/m), or more typically as milli Siemens per meter (mS/m). The Siemen, denoted as S, is defined as the inverse of the Ohm (Ω), the standard unit of electrical resistance.

3.5. Resistivity

The word "resistivity" refers to the quality of a material that governs how well it blocks the flow of an electric current. Electrical conductivity, measured as the ratio of the applied electrical field to the resulting electrical current density, is a material's defining property.

Simply put, a substance's resistivity may be thought of as a numerical representation of how well or poorly it allows electric current to flow. Materials exhibiting high resistivity possess a pronounced level of electrical resistance and exhibit limited conductivity towards electric current. The opposite is true of low-resistivity materials, which exhibit improved conductivity regarding electric current due to their reduced electrical resistance.

The resistivity of a material can be affected by various factors, such as temperature, pressure, including the presence of impurities or defects within the material. As an example, it is observed that the resistivity of the majority of metals exhibits an upward trend as temperature rises, while semiconductors show a drop in resistance as temperature increases.

The attribute of resistivity has significant importance in several electrical applications, as it serves the purpose of assessing the electrical conductivity and efficiency of a given material. Understanding the resistance of a particular substance is also crucial when developing electric parts like cables as well as circuit boards.

4. Experimental Setup

Figure 4 Transformer oil apparatus

Parts:

- Main switch
- Fuse
- Main pilot lamp L1
- HT off push button
- Motor control switch
- HT on pilot lamp
- Kilo voltmeter
- L & N reserve pilot lamp
- Earth open pilot lamp

4.1. Experimental Procedure

- The procedure for this test involves the application of an ascending alternating current (AC) voltage, with a frequency range of 40-60 Hz, to the electrodes. The voltage is systematically incremented by 2 kilovolts every second, commencing at zero and persisting until the voltage attains a threshold that induces breakdown. Fig 4 illustrates about the transformer oil apparatus
- The experiment will be conducted six times with the same cell filling.
- The first voltage utilization should be promptly conducted after the cell has been filled, ensuring the absence of air bubbles and the presence of oil. This should be done within a maximum of 10 minutes after the filling process, subsequent to any previous breakdown.
- The oil is carefully agitated inside the confines of the electrodes using sterile and desiccated glassware, with the objective of reducing the production of air bubbles. This process is conducted in order to condition the oil for later flue gas analysis. The voltage is reestablished after a one-minute interval after the dissipation of any potential air bubbles. The absence of air bubbles is noted as a signal for the optimal time of voltage reapplication.

5. Results

5.1. Break Down Voltage

Figure 5 illustrates the graph depicting the relationship between the concentration of corn oil BD20 mixed with varying percentage of base lubricant (20W-40T) and the corresponding breakdown voltage. It has been discovered that the voltage required for breakdown exhibits an increasing trend when the percentage of base lubricant is increased, up to a concentration of 40% of 20W-40T [20]. The minimal breakdown voltage observed is 48 kV while using corn oil biodiesel which is denoted as BD20 and the maximum value is found to be 66 kV while using 60% Corn Oil (BD20) with 40% 20W-40T.

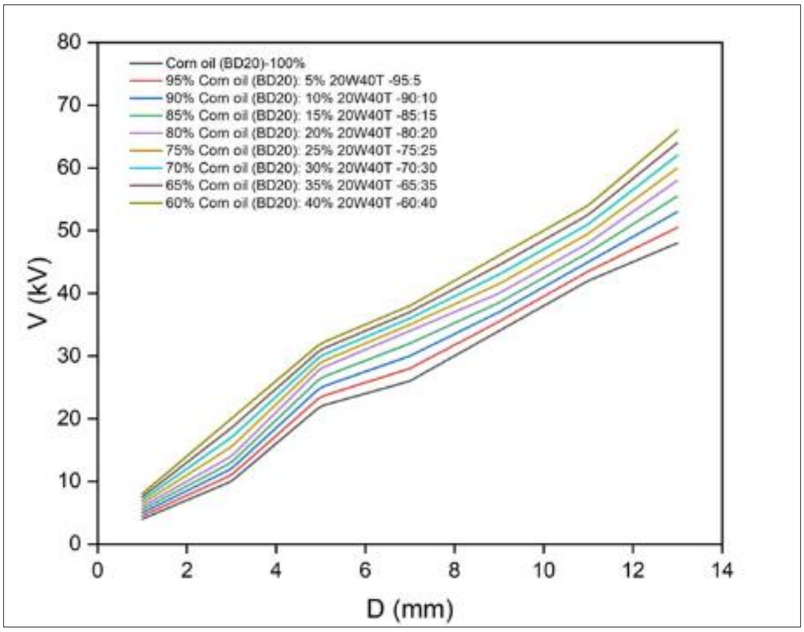

Figure 5 Weight percent Vs Breakdown Voltage for Corn oil BD20

5.2. Electrical Conductivity

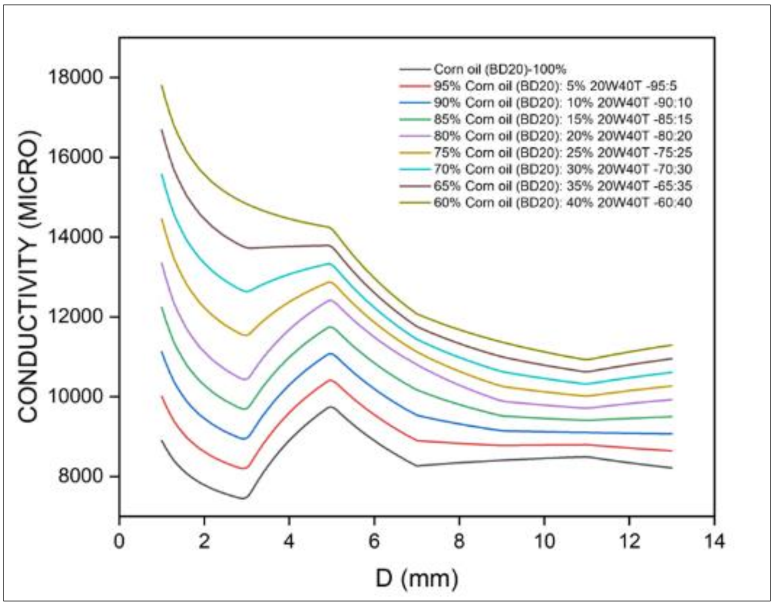

Figure 6 Weight percent Vs Electrical Conductivity for Corn oil BD20

The plot of the Electrical Conductivity vs the weight percent for Corn oil BD20 mixed with varying percentage of base lubricant (20W-40T) is shown in Figure 7. The values of dielectric constant seem to follow a decline trend from 1 mm diameter to 3 mm diameter later there is an increase in the value up to 5mm diameter [21]. This trend again seems to be declined up to 7mm diameter and then followed a linear trend up to the end. The maximum electrical conductivity was found to be for 60% Corn Oil (BD20) with 40% 20W-40T having a value of 11291.69 and the minimum value was found to be for corn oil biodiesel BD20 with a value of 8212.14.

5.3. Dielectric constant

The plot of the Dielectric Constant vs the weight percent for Corn oil BD20 mixed with varying percentage of base lubricant (20W-40T) is shown in Figure 7. The values of dielectric constant seem to follow a decline trend from 1 mm diameter to 3 mm diameter later there is an increase in the value up to 5mm diameter. This trend again seems to be declined up to 7mm diameter and then followed a linear trend up to the end. The maximum dielectric constant was found to be for 60% Corn Oil (BD20) with 40% 20W-40T. Having a value of 5.08 and the minimum value was found to be for corn oil biodiesel BD20 with a value of 3.69 [22].

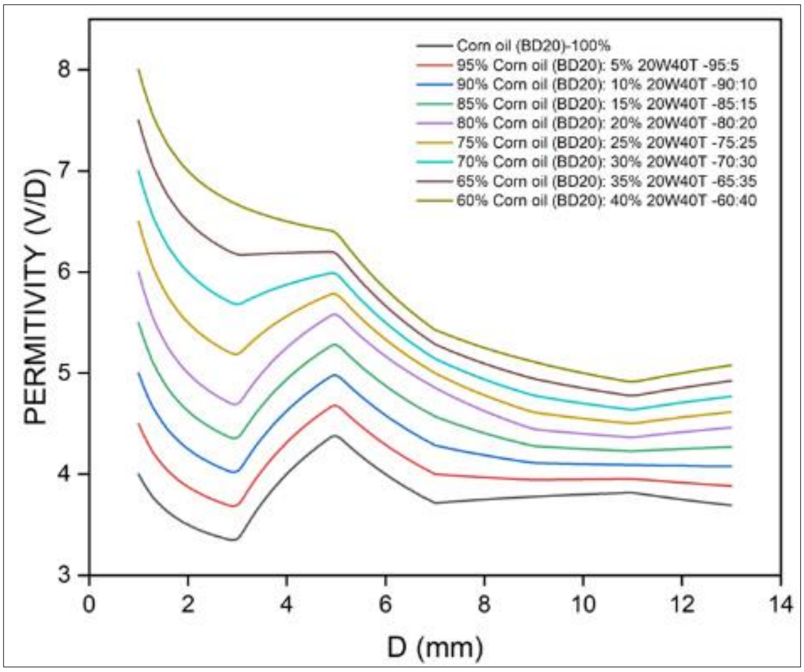

Figure7 Weight percent Vs Permittivity for Corn oil BD20

5.4. Resistivity

Figure 8 provides an explanation. The plot of the Resistivity vs the weight percent for Corn oil BD20 mixed with varying percentage of base lubricant (20W-40T) is shown in Figure 7. The values of dielectric constant seem to follow a decline trend from 1 mm diameter to 3 mm diameter later there is an increase in the value up to 5mm diameter. This trend again seems to be declined up to 7mm diameter and then followed a linear trend up to the end. The maximum resistivity is found to be 121.77 for BD20 and the minimum value is found to be 88.56 for 60% Corn Oil (BD20) with 40% 20W-40T [23].

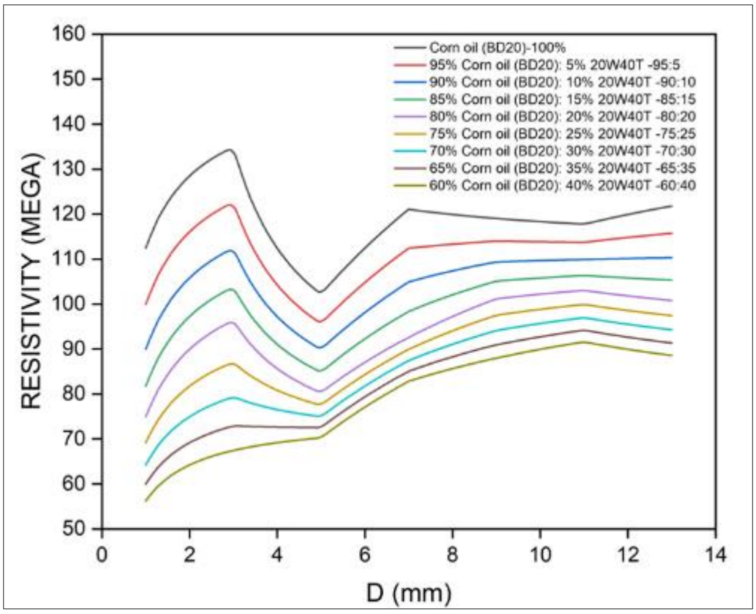

Figure 8 Weight percent Vs Resistivity for Corn oil BD20

6. Conclusions

- Transesterification is a promising and significant method for the manufacture of biodiesel, and further studies and research in this subject is expected to contribute to even greater advances in both the sustainability and effectiveness of biodiesel production.
- the biodiesel is combined with a base lubricant (20W-40T) in varying proportions, spanning from 5% to 40% of the overall volume for improving engine performance and reducing emissions. Further research and development are needed to optimize the blending process and fully assess its potential benefits and drawbacks.
- The minimal breakdown voltage observed is 48 kV while using corn oil biodiesel which is denoted as BD20 and the maximum value is found to be 66 kV while using 60% Corn Oil (BD20) with 40% 20W-40T
- The maximum electrical conductivity was found to be for 60% Corn Oil (BD20) with 40% 20W-40T having a value of 11291.69 and the minimum value was found to be for corn oil biodiesel BD20 with a value of 8212.14.
- The maximum dielectric constant was found to be for 60% Corn Oil (BD20) with 40% 20W-40T. Having a value of 5.08 and the minimum value was found to be for corn oil biodiesel BD20 with a value of 3.69.
- The maximum resistivity is found to be 121.77 for BD20 and the minimum value is found to be 88.56 for 60% Corn Oil (BD20) with 40% 20W-40T.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] A. Franco Jr., H.V.S. Pessoni, T.E.P. Alves Enhanced dielectric permittivity on yttrium doped cobalt ferrite nanoparticles

[2] Cabaleiro J-M, Paillat T, Artana G, Touchard G. Flow electrification in turbulent flows of liquids—comparison of two models for one specific case. IEEE Trans Ind Appl 2019;55(5):5235–8.

[3] R. Surakasi, Y. Srinivasa Rao, Sd. A. Kalam, and N. Begum, “Emissions and Performance of Diesel Engines Correlated with Biodiesel Properties,” Journal of Engineering, vol. 2023, pp. 1–4, Apr. 2023, https://doi.org/10.1155/2023/5274325

[4] Kolcunova ´ I, Kurimský J, Cimbala R, Petra˘˝s J, Dolník B, Dˇzmura J, et al. Contribution to static electrification of mineral oils and natural esters. J Electrostat 2017;88:60–4

[5] García-Morales M, Fernandez-Silva ´ SD, Roman C, Delgado MA. Electro-active control of the viscous flow and tribological performance of ecolubricants based on phyllosilicate clay minerals and castor oil. Appl Clay Sci 2020; 198:105830.

[6] Corach J, Colman M, Sorichetti PA, Romano SD. Kinematic viscosity of soybean biodiesel and diesel fossil fuel blends: estimation from permittivity and temperature. Fuel 2017; 207:488–92.

[7] J. Arunprasad, Alla Naveen Krishna, Dharavathu Radha, Mandeep Singh, Raviteja Surakasi, Tewodros Derese Gidebo, "Nanometal-Based Magnesium Oxide Nanoparticle with C. vulgaris Algae Biodiesel in Diesel Engine", Journal of Nanomaterials, vol. 2022, Article ID 1688505, 9 pages, 2022. https://doi.org/10.1155/2022/1688505

[8] Corach J, Galvan ´ EFern´ andez, SorichettiPAníbal, Romano SD. Broadband permittivity sensor for biodiesel and blends. Fuel 2019;254:115679.

[9] Corach J, Sorichetti PA, Romano SD. Permittivity of diesel fossil fuel and blends with biodiesel in the full range from 0% to 100%: application to biodiesel content estimation. Fuel 2017; 188:367–73.

[10] C.G. Aswin, A. Kumareswaran, R. Lakshmanan, S. Mathavan, V. Andal, R. Lakshmipathy, and Ivan Leandro Rodriguez Rico. Comparative Analysis of NOx Emission Reduction in Engines Using NiCo2O4 Nanoparticles without External Reductant at Low Temperatures: An Experimental Investigation. Journal of Nanomaterials. 2022. Article id: 8981350.

[11] Pakalapati, J., Surakasi, R., Kilari, A., & Nagamani, K. (2024). Nano-dispersed Corn Oil Biodiesel: An Analysis of its Potential for usage in Hybrid Electric Vehicles. International Journal of Vehicle Structures and Systems, 16(1).

[12] Corach J, Galvan ´ EFern´ andez, SorichettiPAníbal, Romano SD. Estimation of the composition of soybean biodiesel/soybean oil blends from permittivity measurements. Fuel 2019; 235:1309–15.

[13] S. Silitonga, H. O. Hamdan, A. S. Othman, et al. "Influence of the blending ratio on the electrical conductivity and dielectric constant of palm oil biodiesel." Energies 10.7 (2017): 918.

[14] R. Surakasi, G. C. Sekhar, J. Pakalapati, R. Pakalapati, and M. Rafeeq, "Evaluation of electrical properties of graphene nanopowder-dispersed propylene glycol-water solutions," Engineering Research Express, vol. 5, no. 3, p. 035019, Jul. 2023, https://doi.org/10.1088/2631-8695/ace58e

[15] M. Arulmozhi, S. K. Nema, P. Selvakumar, et al. "Experimental investigation of electrical conductivity and viscosity of biodiesel blends." Journal of the Energy Institute 91.1 (2018): 63-70.

[16] S. Karthikeyan, A. Prathima, M. Periyasamy and G. Mahendran "Performance analysis of Al2O3 and C18H34O2 with KappaphycusAlvarezil-Brown algae biodiesel in CI engine," Elsev. Mater. Today Proceed., vol.33, pp.4180–4184, 2020

[17] Characterization and Evaluation of Electrical Properties of Corn Oil Biodiesel mixed with Nano Additive," International Journal of Renewable Energy Research, no. V13i2, 2023, https://doi.org/10.20508/ijrer.v13i2.14144.g8742

[18] Kole M and Dey T K 2014 Study of electrical conductivity of Al2O3/water nanofluid. international journal of advanced research in electrical Electronics and Instrumentation Engineering 3 12317–21

[19] Raviteja Surakasi, Balakrishna Gogulamudi, Alla Naveen Krishna, Raja Ambethkar M, Pravin P. Patil, Pradeep Jayappa, "Optimization of the Process of Metal NanoCalcium Oxide Based Biodiesel Production through Simulation Using SuperPro Designer", Journal of Engineering, vol. 2022, Article ID 3473356, 6 pages, 2022. https://doi.org/10.1155/2022/3473356

[20] Haribabu, A., Surakasi, R., Thimothy, P. et al. Study comparing the tribological behavior of propylene glycol and water dispersed with graphene nanopowder. Sci Rep 13, 2382 (2023). https://doi.org/10.1038/s41598-023-29349-7

[21] A. Jayanthi, R. Krishna Priya, Raviteja Surakasi, Jaya Prasad Vanam, G. Puthilibai, M. Santhanakrishnan, S. Rajkumar, Mechanical and tribological properties of TiC nano particles reinforced polymer matrix composites, Materials Today: Proceedings, Volume 59, Part 2, 2022, Pages 1472-1477, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2022.01.096.

[22] Surakasi, R., Sekhar, K.C., Kavitha, E. et al. Evaluation of physico-thermal properties of TiO2–water mixture dispersed with MWCNTs. Nanotechnol. Environ. Eng. 7, 325–331 (2022). https://doi.org/10.1007/s41204-022-00242-4

[23] Surakasi R, Sripathi S, Nadimpalli SP, et al. Synthesis and Characterization of TiO2-Water Nanofluids. Adsorption Science & Technology. 2022;2022. doi:10.1155/2022/3286624