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Biodiesel Production from Calophyllum Inophyllum Oil using Ultrasonication Method and Investegation of its Properties with Diesel and Kerosene Blends

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Abstract: From the last few years, the efforts have been doubled to replace fossil fuels with clean and renewable resources. Among renewable resources, biodiesel is a promising one in transportation sector. In this study, biodiesel was produced from high FFA Calophyllum inophyllum oil in ultrasonicator. Since the initial FFA of crude Calophyllum inophyllum oil was very high of 18.33%, biodiesel production was done in three stages i.e. two stages of esterification process followed by transesterification process. 96% of biodiesel yield was achieved. The properties of biodiesel and its blends with diesel and kerosene have been studied.

***Keywords*: Calophyllum Inophyllum, Ultrasonicator, Transesterification, Biodiesel, Blending**

I. INTRODUCTION

Today, rise in global population has led to large increase in the energy demand, which has resulted in the depletion of natural energy resources [2]. Excessive use of fossil fuels has severely affected the climatic conditions in the form of greenhouse effect. This has forced researchers to look for a clean and alternative fuel [1]. Biodiesel is a good alternative fuel for fossil fuels since they are biodegradable, eco-friendly, sulphur free and renewable in nature [3] [4]. Biodiesel can be defined as mono alkyl esters of long chain fatty acid derived from vegetable oil or animal fat [4]. Calophyllum Inophyllum tress commonly known as Polanga, Beauty leaf, Surahonne etc. is a multipurpose tree found in Philippines, malnesia and Polynesia [5]. In Karnataka it can be found in Western Ghats. It requires 1000-5000 mm rainfall. The height ranges between 8m to 20m at full maturity condition. The tree is also used for decorational purpose. Similarly leaves of the tree have medicinal values [7]. The seeds found in the tree are dark green colour and contain pale yellow coloured kernel. Single tree can produce oil content in the range of 11.7 kg to 18kg of oil [5] [6].

In this study, Calophyllum Inophyllum biodiesel was produced using sulphuric acid (H_2SO_4) and sodium hydroxide (NaOH) and as acid and base catalyst for esterification and transesterification process respectively. The properties of obtained biodiesel were checked and it was blended with diesel and kerosene. Variation in the properties of the blends was studied. Section II describes the step by step procedure of biodiesel production. Section III presents experimental results showing variation in the properties of the blends. Finally Section IV presents conclusion.

II. METHODOLGY

Step by step procedure of production of Calophyllum inophyllum biodiesel is given below:-

A. Extraction of Crude Oil

The seeds were collected from local farmers around Mysuru region. The collected seeds were dried under sun for 4-5 days. The dried seeds were separated from small stones and other dust particles and were later crushed in a mechanical expeller located in Biofuel Park, Hassan. An oil yield of around 50-55% was obtained.

B. Properties of Crude Oil

The extracted crude Calophyllum inophyllum oil was allowed to settle down in a medium sized container to remove the dirt particles mixed in the oil. After settling, pure crude oil was separated and it was stored in a air tight container. In the department laboratory, different properties of oil like Density, Kinematic Viscosity, Flash point, Calorific value were tested using simple weigh balance, redwood viscometer, Pensky martin apparatus and bomb calorimeter respectively. The values of different properties of the

oil was found to be Viscosity at 40°C (mm^2/s) 53.422, Density at 40°C (kg/m^3) 855.7, Flash Point (°C) 220, Specific Gravity 0.925 and Calorific value (kJ/kg) 38,826. After evaluation of the above properties, the Free Fatty Acid Content (FFA) of the oil was tested. A high FFA of 18.33% was obtained.

C. Esterification Process

The FFA content of the crude oil should be below 4% for the transesterification process to be effective [8].otherwise high FFA can lead to soap formation and reduce biodiesel separation ability from glycerol. Hence high FFA crude Calophyllum Inophyllum oil was first subjected to two stage esterification processes using sulphuric acid (H_2SO_4) as catalyst and methanol as reacting agent where the high FFA content of the crude oil was converted into triglycerides.

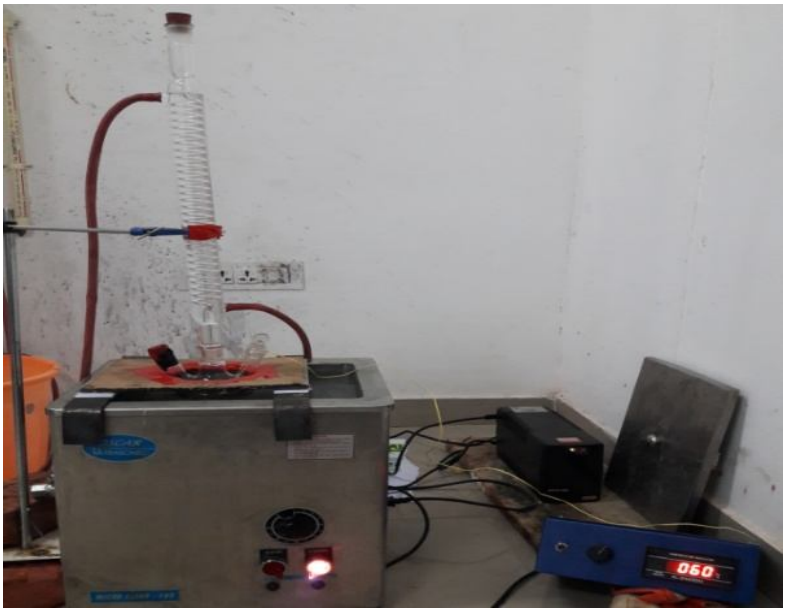

Fig. 1 Ultrasonicator Set-up for Biodiesel Production with Condenser and Digital Thermocouple

Initially, the crude oil was preheated to 110 °C for duration of half an hour to remove the moisture content. The water particles present in the oil can react with catalyst leading to saponification reaction [2]. Hence the moisture content is removed before beginning of the process. Both esterification and transesterification process were carried out in a ultrasonicator fitted with condenser and digital thermocouple as shown in above Fig 1. In ultrasonicator, sound waves are generated and made to pass through water bath. During the wave's passage through water bath, bubble cavitation occurs which causes micro-level mixing of alcohol and oil which are immiscible in nature [9]. For first and second stage, Methanol-oil molar ratio of 6:1 and 4:1, Catalytic Concentration of 1.2% and 0.8% (% by W), reaction time of one hour and reaction temperature of 55 to 60 °C were maintained. After the completion of process, the product was allowed to settle down in the separatory tank, to remove excess methanol, catalyst and other impurities which had got collected at top portion of the tank. The efficiency of the esterification stage was found to be 90%. The FFA content of esterified oil after first and second stage was found to be 4.52% and 2.82% respectively.

D. Transesterification Process

Transesterification is a chemical reaction process of converting triglycerides into mono-alkyl esters and glycerol by reacting it with alcohol (methanol or ethanol) in the presence of catalyst [10]. Different combinations of Methanol-oil molar ratio, Catalytic Concentration and reaction time were tried to achieve maximum biodiesel yield. A maximum biodiesel yield of 96% was obtained for 9:1 molar ratio, 0.5% catalyst concentration and reaction time of 60 minutes. Temperature was maintained 55 to 60 °C during entire process. The product obtained was allowed to settle in a separatory funnel, where by-products of the reaction was removed from the bottom and top layer biodiesel was collected and stored in air tight container.

E. Properties of Calophyllum Inophyllum Biodiesel

In the department laboratory, different properties of oil like Density, Kinematic Viscosity, Flash point, Calorific value were tested using simple weigh balance, redwood viscometer, Pensky martin apparatus and bomb calorimeter respectively. The values of different properties of the oil was found to be Viscosity at 40°C (cSt) 5.2, Density at 40°C (kg/m^3) 892, Flash Point (°C) 75, Fire Point of (°C) 84,Cloud point and Pour points 12 °C and 10 °C and Calorific value (kJ/kg) 39614.

F. Blending of Calophyllum Inophyllum Biodiesel with Conventional Diesel and Kerosene

Calophyllum Inophyllum biodiesel was blended with conventional diesel and kerosene in the following proportions:-

B10 ⟶ 10% Biodiesel + 90% Diesel
B20 ⟶ 20% Biodiesel + 80% Diesel
B30 ⟶ 30% Biodiesel + 70% Diesel
B40 ⟶ 40% Biodiesel + 60% Diesel
B10K5 ⟶ 10% Biodiesel + 85% Diesel+5% kerosene
B10K10 ⟶ 10% Biodiesel + 80% Diesel + 10% kerosene

III. EXPERIMENTAL RESULTS

A. Variation of Density for Different Biodiesel-Diesel-Kerosene Blends

Density of Biodiesel depends upon molecular weight. Since the density of Calophyllum Inophyllum biodiesel is more than conventional diesel fuel, the density of different blends increases with the increase in biodiesel percentage and same can be observed in the Fig 2. Similarly when kerosene is added to biodiesel-diesel blends, decrease in density was observed with the increase in kerosene percentage since the density of kerosene is less than biodiesel and conventional diesel. Calophyllum Inophyllum Biodiesel has maximum density of 892 kg/m^3 and Kerosene has a minimum density of 790 kg/m^3. Among blends B10K10 has density close to Diesel value i.e. 818.04 kg/m^3.

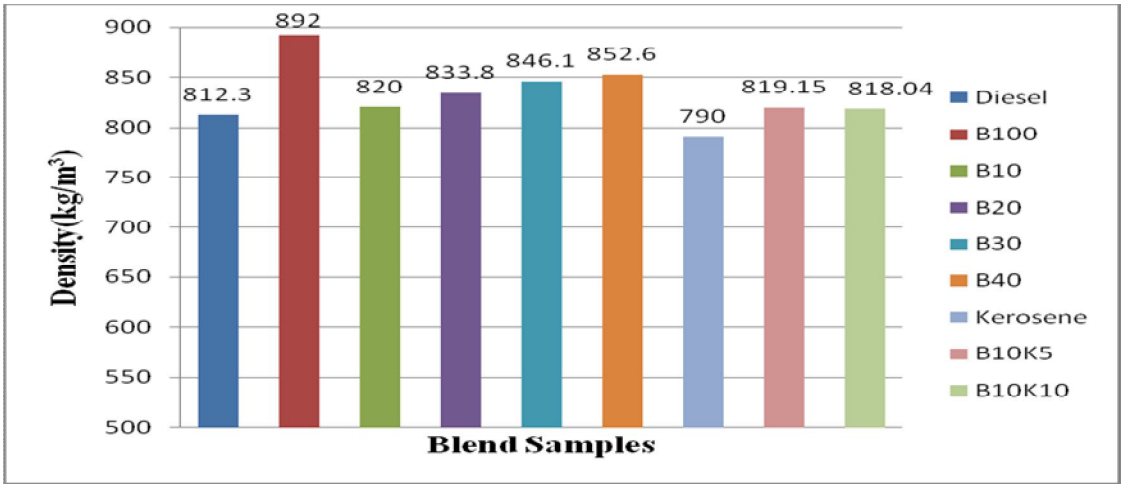

Fig. 2 Variation in Density

B. Variation of Kinematic Viscosity for Different Biodiesel-Diesel-Kerosene Blends

Viscosity is one of the most significant properties of biodiesel since it plays a vital role in fuel injection process of diesel engine. If the viscosity is high it affects atomization process because of which effective mixing of fuel with air will not takes place and it inturn causes incomplete combustion [11]. Viscosity will be high for those oils having longer chain length of fatty acid and is less for those oils having more amount of unsaturated fatty acid (oleic acid, linolenic acid etc) [1] [12]. From Fig 3 it can be observed that Calophyllum Inophyllum Biodiesel has highest viscosity of 5.32 cSt. Among blends B10K10 has viscosity nearer to diesel value i.e. 1.936 cSt. Since viscosity of kerosene is less compared to biodiesel and diesel fuel, addition of kerosene to biodiesel-diesel blends reduces viscosity of blends.

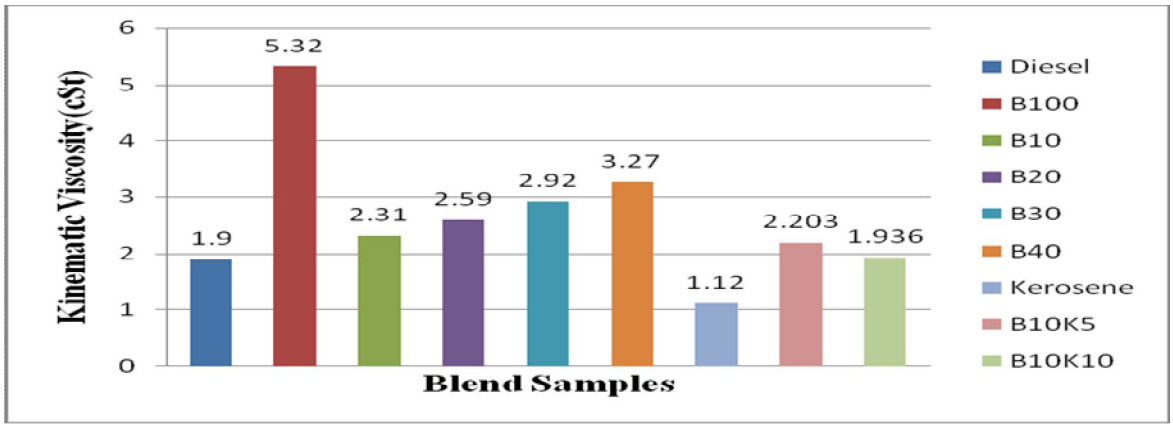

Fig. 3 Variation in Kinematic Viscosity

C. Variation of Flash Point and Fire Point for Different Biodiesel-Diesel-Kerosene Blends

Flash Point is an important property to be considered during fuel storage [12]. Higher the flash point of fuel it is safer during stored conditions. Flash point of a biodiesel is determined by its structure and alcohol content present in it [11] [1]. From Fig 4 it can be observed that Calophyllum Inophyllum Biodiesel has highest flash point of 184ºC. Hence as biodiesel percentage increases in the blends there is an increase in flash point. Among blends B10K10 has flash point nearer to diesel value i.e. 79ºC. Since flash point of kerosene is less, addition of kerosene to biodiesel-diesel blends reduces flash point of the blends. Similarly from Fig 5 it can be observed that Calophyllum Inophyllum Biodiesel has highest fire point of 192ºC. Hence as biodiesel percentage increases in the blends there is an increase in fire point. Among blends B10K10 has fire point nearer to diesel value i.e. 86ºC. Since fire point of kerosene is less compared to biodiesel and diesel fuel, addition of kerosene to biodiesel-diesel blends reduces fire point of the blends.

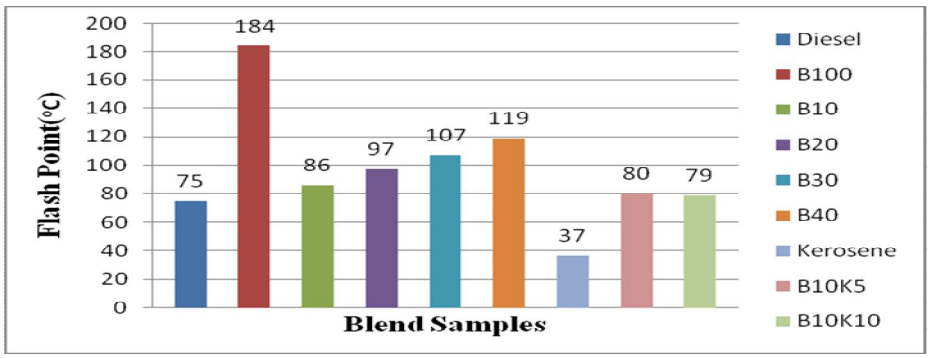

Fig. 4 Variation in Flash Point

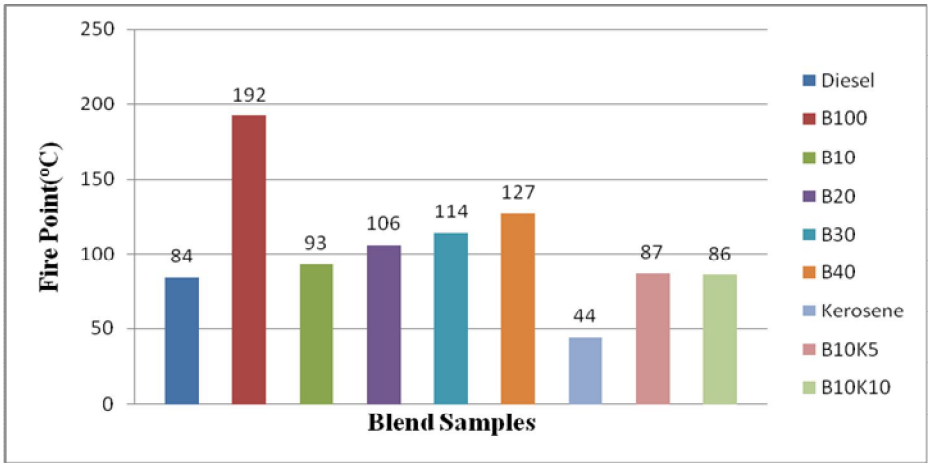

Fig. 5 Variation in Fire Point

D. Variation of Calorific Value for Different Biodiesel-Diesel-Kerosene Blends

Calorific value of fuel is one of the important parameter that determines efficiency of an engine. Higher the calorific value of a fuel, larger amount of heat will be released which increases the efficiency of the engine. From Fig 6 it can be observed that as biodiesel percentage in blends increases there is a decrease in calorific value. It is because of the reason that since Biodiesel is an oxygenated fuel; its calorific value is less compared to diesel [11]. Diesel has a highest calorific value 44800 kJ/kg and among blends B10K10 has calorific value nearer to diesel value 44341.4 kJ/kg. Since calorific value of kerosene is more compared to biodiesel, addition of kerosene to biodiesel-diesel blends increases calorific value of the blends.

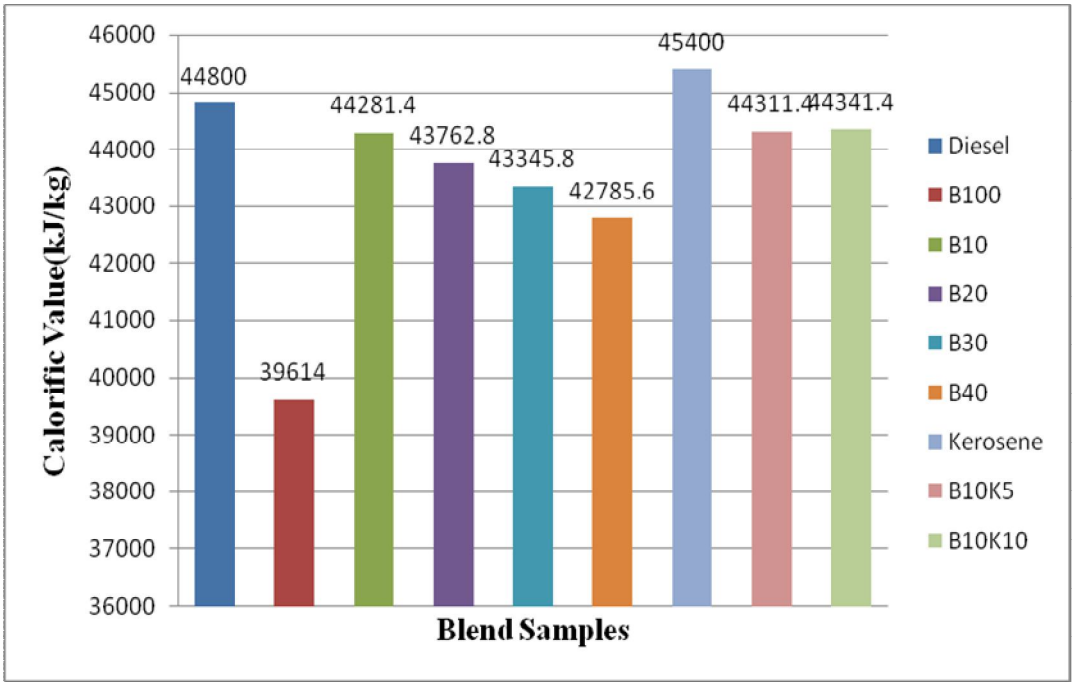

Fig. 6 Variation in Calorific Value

E. Variation of Cloud Point and Pour Point for Different Biodiesel-Diesel-Kerosene Blends

From the test conducted for cloud and pour point temperature, it was found that Calophyllum Inophyllum Biodiesel has highest cloud point temperature of 12 °C and pour point temperature of 10°C. From the Fig 7 & Fig 8 it can be observed that with increase in biodiesel percentage in the blends there is an increase in cloud point and pour point temperatures respectively.

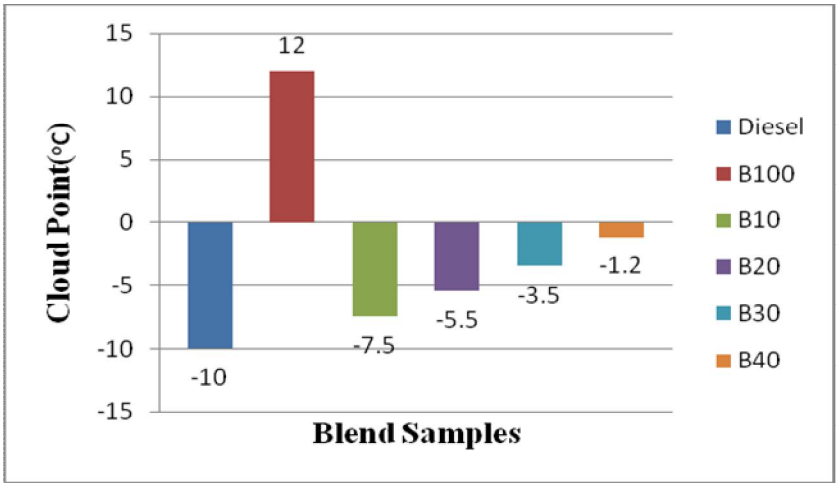

Fig. 7 Variation in Cloud Point

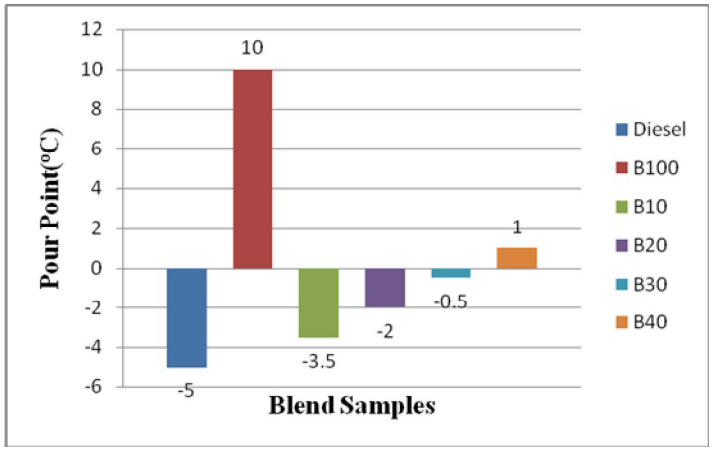

Fig. 8 Variation in Pour Point

IV. CONCLUSIONS

Calophyllum Inophyllum Biodiesel is a promising source that can be used as supplement for conventional diesel fuels. They can be grown in barren lands with average rainfall conditions. The oil yield of seeds is also good. The properties of biodiesel tested were within ASTM standard limits. The blend B10K10 properties were close to diesel properties. Addition of kerosene to biodiesel-diesel blends reduces viscosity which inturn increases the fuel atomization resulting in good combustion. Calorific value of kerosene is more compared to diesel and biodiesel, its additions to blends results in increase of calorific value.

V. ACKNOWLEDGMENT

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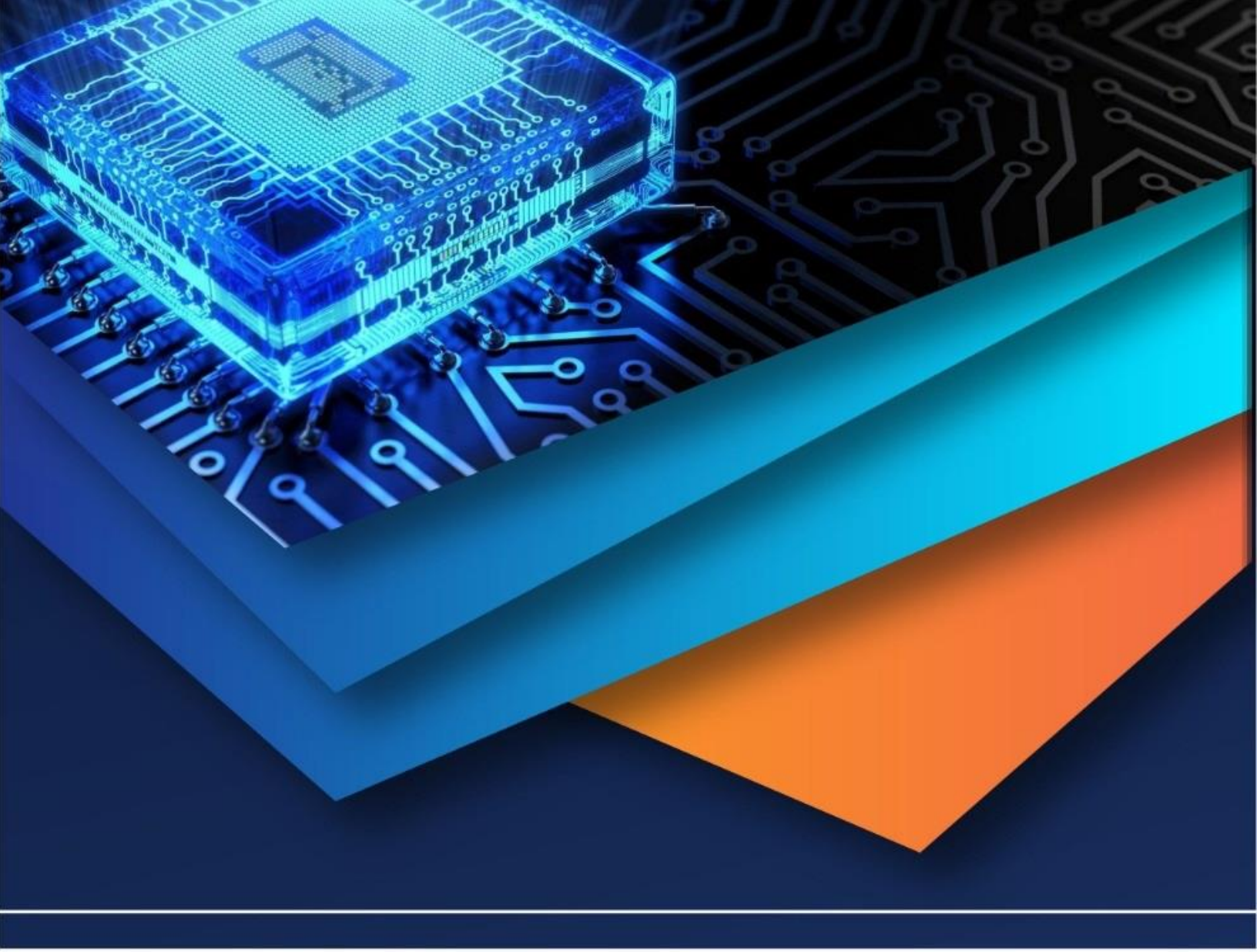
REFERENCES

[1] R.A. Candeia, M.C.D. Silva, J.R. Carvalho Filho, M.G.A. Brasilino, T.C. Bicudo, I.M.G. Santos, A.G. Souza. Influence of soybean biodiesel content on basic properties of biodiesel–diesel blends; 2008
[2] Vivek Rathore , Bharat L. Newalkar , R.P. Badoni Processing of vegetable oil for biofuel production through conventional and non-conventional routes ; 2016
[3] Mohammed Takase, Weiwei Feng,WeiWang, Xiaoyun Gu, Yang Zhu, Ting Li, Liuqing Yang , Xiangyang Wu. Silybum marianum oil as a new potential non-edible feedstock for biodiesel: A comparison of its production using conventional and ultrasonic assisted method; 2014
[4] Vlada B. Veljkovi´c, Jelena M. Avramovi´ c, Olivera S. Stamenkovi´c. Biodiesel production by ultrasound-assisted transesterification: State of the art and the perspectives;2011
[5] B.K. Venkanna , C. Venkataramana Reddy. Biodiesel production and optimization from Calophyllum inophyllum linn oil (honne oil) – A three stage method; 2009.
[6] S.M. Ashrafur Rahman, H.H. Masjuki, M.A. Kalam, M.J. Abedin, A. Sanjid, H. Sajjad. Production of palm and Calophyllum inophyllum based biodiesel and investigation of blend performance and exhaust emission in an unmodified diesel engine at high idling conditions; 2013.
[7] A.E. Atabani, Aldarada Silva César. Calophyllum inophyllum L. A prospective non-edible biodiesel feedstock. Study of biodiesel production, properties, fatty acid composition, blending and engine performance; 2014.
[8] I.M. Rizwanul Fattah, H.H. Masjuki, M.A. Kalam, M.A. Wakil, A.M. Ashraful, S.A. Shahir. Experimental investigation of performance and regulated emissions of a diesel engine with Calophyllum inophyllum biodiesel blends accompanied by oxidation inhibitors; 2014
[9] Nur'Atiqah Mohd Shamsuddin, Suzana Yusup, Wan Asma Ibrahim, Awais Bokhari, Lai Fatt Chuah. Oil Extraction From Calophyllum inophyllum L. via Soxhlet Extraction Optimization Using Response Surface Methodology (RSM); 2015
[10]Z. Helwani, M.R. Othman, N. Aziz, J. Kim, W.J.N. Fernando. Solid heterogeneous catalysts for transesterification of triglycerides with methanol: A review; 2009
[11]A.M. Ashraful , H.H. Masjuki, M.A. Kalam, I.M. Rizwanul Fattah, S. Imtenan, S.A. Shahir, H.M. Mobarak. Production and comparison of fuel properties, engine performance, and emission characteristics of biodiesel from various non-edible vegetable oils: A review; 2014
[12]L.C. Meher, D. Vidya Sagar, S.N. Naik. Technical aspects of biodiesel production by transesterification—a review; 2004



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