International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-1, May 2020

Synthesis and Testing on Engine Characteristics of Bio-diesel Obtained by Orange-Peel Oil Methyl Ester Blended with Conventional Diesel Fuel.

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***Abstract**: The increase in demand and depletion of fossil-fuels, due to the population growth, which led the rise in use of vehicles and transportation sector. The ever increasing environmental issues and the rising cost of fossil fuels in the world market have also contributed an opportunity for the researchers to develop a potential alternative fuel. Among of this concept, the alternative fuel must be attractive such as diesel in efficiency and eco-friendly. Thus the characteristics of biodiesel have made the historical background of attractive qualities in efficiency. The bio-diesel production has turn out to be more attractive at the present time period, because of its benefits over environmental issues and the truth that, it is made from renewable and environmentally available resources. Although in most of the countries orange-peels are considered as waste. The utilization of peels instead of edible parts of the resources in reducing the cost of biodiesel production to a great extent. The research study is intended to transform the waste resources into wealthy product, and essential product is obtained by establishing the production of bio-diesel with oil extracted from orange-peels; using the transesterification process. The fatty acid composition of the feedstock is studied by gas chromatography mass spectroscopy method and FT-IR test.*

This experimental work is carried out to study the physio-chemic properties, and to study the four stroke diesel engine performance and emissions characteristics, fueled with orange-peel oil methyl ester biodiesel blends at different concentrations (10, 20, and 30) percentages with diesel fuel. The results obtained are in close agreement with the requirement of ASTM biodiesel standards. It has been establish that at peak load conditions, the higher blend percentage of biodiesel shows better and higher output performance than that of conventional diesel fuel. Emissions characteristics were also found to be reduced to great extent. From the available resources it is confirm that the better combustion characteristics is due to the oxygenated fuel content called limonene compound in the biodiesel feedstock. Another end product of transesterfication process called glycerol, was recycled twice before it finally lost potential and further it can be used as constituents for the soap manufacturing process.

Keywords: Bio-diesel, Transesterification, Orange-peel Oil, Soxhlet extractor

Manuscript received on May 14, 2020.
Revised Manuscript received on May 26, 2020.
Manuscript published on May 30, 2020.

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I. INTRODUCTION

Due to the increase in prices of diesel-fuel and petroleum products around the world, growing environmental emission norms have impelled the researchers to find an alternative-fuel. For the past few decades the situation is getting hard due to the increase in population all around the world. The limitation of traditional fuels resources in the earth, due to its over consumption, the resources were exploiting by the mining companies for daytoday use in several sectors from burning igniter to transportation purpose. Not only the scarcity in fossil fuels, but also the growing emissions from the industries and transporting vehicles. These are the well-known problems are arising from the conventional petroleum fuel products. Experts from the several sectors suggest that the current petroleum products will lasts for only few decades. To overcome the energy demand in the growing world and reducing petroleum reserves, fuels such as bio-fuels are in forefront of the alternative technologies. Accordingly, from the available resources, the bio-fuels from the natural resources are only applicable for compression ignition diesel engines. The vigorous demand of energy resources in the automotive segment, the alternative fuel such as bio-diesel can only overpass the gap amongst the diesel engine applications [1]. The advantages of bio-diesel over diesel fuel being the attractive part of the alternative fuel suggestion in the current scenario, such as: Bio-degradable resource, and being readily available in nature, non-toxic characteristics and renewable form of energy are the major parts of it. The basic structure of bio-diesel derived from the vegetable oils consist of mono-alkyl esters of fatty acids, which shows great importance in the potential as alternative fuel to diesel fuel [2]. Recently, based on the experimental investigation the diesel engine fueled with biodiesel offer better advantages in flash point, fire point, cetane number, low viscosity, and eco-friendly due to the less carbon mono-oxide emissions, as well as lesser emission profiles over conventional diesel fuels without any engine modifications.

Due to these major benefits the production of biodiesel derived from feedstocks such as animal fats and vegetable oils are been restored [3, 4]. In the starting of twentieth century, during the First World War, the diesel engines were fed with bio-diesel-fuel derived from vegetable-oils as fuel, with some modifications. Then it was concluded that the engines could be fed with feedstocks of vegetable-oils as fuel [5]. In addition to that, the Bio-diesel-fuel can either used as a pure form or blended form with diesel-fuel that can also reduce the particulate emissions from the engine [6]. Different varieties of Bio-diesel can be extracted from modified feedstocks (vegetable-oils) such as rapeseed, canola, palm, jatropha, palm kernel, sunflower, and coconut. These feedstocks have been studied as precursors for bio-diesel production and some of those sources are edible feedstocks in nature. The main concern about bio-diesel production is because of the inflated price of vegetable-oils available in the market are compared to that of fossil-based diesel fuel. Most of these oils are used for the bio-diesel production are edible oils, these are expensive and may thus be counter-productive if used on large scale production of bio-diesel [7, 8]. Thus dependence on the production of bio-diesel from edible oils will results in scarcity of food materials for humans and live-stocks in the current scenario. This consideration has made into a conclusion that, the use of non-edible oils instead of edible oils from inexpensive sources such as waste from a product for the production of bio-diesel. As a result, in some of the countries, non-edible oils such as non-edible vegetable, fruit - seeds, peels or waste cooking oils are preferred for the alternative fuel source, due to their low price and abundant availability in nature and market [9]. The blending of bio-diesel with conventional diesel-fuel is another option to reduce the high price of bio-diesel and in this case, the blended bio-diesel product in such a way that non-edible oils with conventional diesel fuel. The first-generation bio-diesel production from non-edible oils has gained attention due to the easy processing and high bio-diesel yield. However, the edible-oil based bio-diesel problems are become more crucial, because of fuel versus food debate. These factors have negatively impacted on the production of bio-diesel from the available edible oils in the current situation. Another important fact is that the government is banned the edible-oil based biodiesel production. Therefore, non-edible vegetables and its products, wastes or the second generation feedstocks (includes waste cooking oils, seed products from content) have become more striking for the biodiesel production [10, 11]. All over the world, there are more than 300 (approx.) crops are acknowledged as a probable feedstock [12, 13].

Fats and oils derived from animals, plants, vegetable, and fruits (it may be edible or non-edible) are primarily water-insoluble (concluded by experiments). From the available resources the feedstocks from the plants are hydrophobic substances. These are made up of one-mole of glycerol and three-moles of fatty-acids and are more commonly referred to as triglycerides. While the crude oil or fats extracted from the vegetable oils contains free-fatty-acids (FFA), phospholipids, water, sterols, odorants, and other impurities [14]. Even refined oils and fats contain small amounts of free fatty-acids (FFA) and water. The free-fatty-acid (FFA) and water contents have significant effects on the process of transesterification of glycerides with alkaline or acid. They also separated with the separating funnel after transesterification process, into of fatty acid esters and glycerol [15 - 18]. There are mainly two primary production methodologies for producing bio-diesel have been studied extensively by researchers and one of the methodologies is adopted here to do this experimental process. Thus the technologies initiating with the direct usage or blending of oils, continuing with pyrolysis and finishing with an emphasis on the current process of choice, called transesterification process. Transesterification is considered as one of the most commercially and experimentally useable methods to produce bio-diesel-fuel and the process involves a reaction between ester (here triglyceride) and alcohol to form new ester (called mono-glycerol) and alcohol. Different types of alcohol have been used, such as methanol, ethanol, propanol, and butanol for the transesterification process. However, methanol and ethanol are the most widely used for the process, most of the researchers particularly prefer methanol, because it owing to its low price and availability [19, 20].

Several investigators related to this field of area, considered the characteristics of engine behavior with varieties of bio-diesels are elicited from diverse feedstocks from non-edible oils, which shows a prominent effect on performance and emission on diesel-engines. Chauhan et al. a young researcher scrutinized the performance of a mono-cylinder Combustion-Ignition Diesel engine runs with fuel as non-edible oil called Jatropha methyl ester blends [21]. Likewise, many of the researchers experimentally show that the usage of bio-diesels in CI Engines improves its performance and reduces its emission. Thus the production of bio-diesel leads to the final conclusion that, the literature studies on several researchers were mainly concentrating on found the feasibility of using new types of bio-diesel obtained from new feedstock such as lemon skin, orange seed, gummi-gutta seed, grass, rubber-seed and pine oil, etc. However, the bio-diesel produced from such novel types of feedstocks resulted in inferior performance on some characteristics such as Brake Thermal Efficiency (BTE), Brake specific fuel consumption (BSFC) and Oxides of Nitrogen (NOx) emissions owing to the existence of evidences and the measure of (Unsaturated Fatty Acids) UFA contents and oxidation stability [22-24].

In this present experimental work, the feedstock called Orange-Peel is allowed to make into oil using soxhlet extractor. The Free-Fatty-Acid (FFA) content of Orange-Peel-Oil (OPO) is referred as 1.1, which is less than 2. So Orange-Peel-Oil (OPO) is directly converted into bio-diesel through transesterification process. The methanol to oil is at a ratio of 3:1, the reaction temperature at 60 ^{0}C. The experimental research starts with the production of Orange-Peel-Oil-Methyl-Ester (called bio-diesel) produced from waste orange-peels, used as a test fuel and the experimental investigation on the effect of engine performance and emission characteristics of Orange-peel oil bio-diesel-fueled on diesel-engine.

II. MATERIALS AND METHODS

A. Extraction of OP Oil

Generally, mechanical crushing, solvent extraction, and enzymatic extraction are some of the oil extraction techniques are adapted for extracting oil from seeds or peels from the feedstock [20]. The yield of the oil is mainly depends up on the technique that is used for extraction of oil from the feedstock. The orange-peels were collected from the whole sale Orange traders at a popular market in Trivandrum and Karunagapally, Kollam districts of Kerala. The peels of orange were sun-dried for a period of 60-80 hrs. The sun-dried peels of orange were milled to powder form with the help of a manual grinder or electric grinder. Make sure that the powder should be powdered at a size less than 1-5mm, shown in Fig.1 (Fig.a) - (the mechanical crushing method is adaptable for the preferable size of the dried OP). The solvent extraction process is prepared in an apparatus shown in Fig.1 (Fig.b) using reacting solvent called n-hexane to extract OP-Oil from sun-dried - powdered peels of orange. The powdered peels of orange weighted 150 Gms are allowed to keep into paper thimble inside the apparatus called soxhlet extractor. The structure of the soxhlet extractor is defined by, a three-way neck round bottom flask of 500ml capacity filled with a solvent called n-hexane, it is placed on the water bath insisted on an electric heater for continues cooling process. The upper section of the Soxhlet extractor apparatus was operated with cooling water. The lower section of the extractor (bottom flask) is filled with n-hexane solvent, and allowed to heated at a temperature of 70 ^{0}C. The evaporated solvent from the flask is conceded all the way through the adjacent tube and it is condensed in the condenser. Then the condensed solvent is directed to the thimble portion and extracts the oil constituents into the flask. The n-hexane and crude Orange-peel oil was separated by volatilize by keeping a fan for a particular time period. The oil was then dried in a hot air oven at a temperature of 70 °C for 30 mins. Then the occurred oil was then allowed to transesterification process for the production of bio-diesel.

Fig.a Dried Orange-peels Cutted into pieces for crushing
Fig.b Solvent extraction using Soxhlet extractor apparatus
Fig.c Extracted Orange-peel oil placed in beaker for volatilize
Fig. 1 Images of Orange-peel Oil extraction process

B. Preparation of Bio-diesel from Orange-peel Oil

Most of the researcher adapted Transesterification process for the preparation of Bio-diesel in laboratory set-up. In this process 20 ml of the crude orange-peel oil was mixed with 60 ml of methanol at a mole ratio of 1:3, 1gm of catalyst called sodium hydroxide is allowed to add into a 250ml glass beaker over a magnetic stirrer cum heating mantle. The mixture is the heated at 80 °C for 2.5 hrs and settled for 36 hrs. Then the mixture of oil is then separated to two different layers (ethyl ester from the other layer - glycerol), with the help of a separating funnel. The purification of the separated methyl ester was prepared with sulphuric acid. The top layer was the methyl ester (fatty acid methyl ester called bio-diesel) [25]. The produced bio-diesel was characterized in accordance with ASTM standards.

C. Bio-diesel Chemical compound Analysis

The chemical analysis of orange-peel-oil consist of mainly two types of techniques to find the properties, to show similarity with the Biodiesel standards. Initially the Fourier Transformed Infrared Spectroscopy (FT-IR) analysis was conducted for the classification of several functional group compounds. Secondly, the Gas chromatography-mass spectrometry (GC-MS) is used to determine the aromatic composition and active aroma compounds of oil. The elemental compounds were also determine from the extracted oil.

1) Gas Chromatography and Mass Spectroscopy (GC-MS) analysis results

Gas chromatography-mass spectrometry (GC-MS) is used to determine the aromatic composition and active aroma compounds of oil extracted from seed, pulp and peel of fruits and vegetables. Here the analysis is for the oil extracted from the peel of the fruit. From the analysis, it is found that the Orange-peel oil consist of volatile content, and it is found to be totals of 32 compounds. From the available results, he major aroma compounds found in OP are hydrocarbons, aldehydes, alcohols, esters, and ketones. It is found to be more than 200 (approx.). The presence of terpenes with the traces of oxygenated components available in the Orange-peel oil shows the aromatic character. [26-31].

2) Volatile components identified in Orange-peel oil by GC-MS test analysis

From the GC-MS test analysis of OP oil extracts, the volatile components are present as a total number of 32 compounds were identified. Among, sixteen of them are hydrocarbons and eight aldehydes, three alcohols, three esters, one ketone and terpenic oxide (Fig. 2). Among these components, limonene was one of the notable volatile components available in greatest concentrations, representing 90.85% of all volatiles. Other pre-dominant components such as β-myrcene, linalool, γ-terpinene, and α-pinene.

In the OP oil extract sample, the major compounds were mono-terpenes and sesquiterpenes. The peel oil contained terpenes at higher levels. Bicyclogermacrene, which had been mentioned in lime oils (particularly percentage level) by the researchers were mentioned [32, 33]. This was found in OP oil in minor amounts (0.01%).

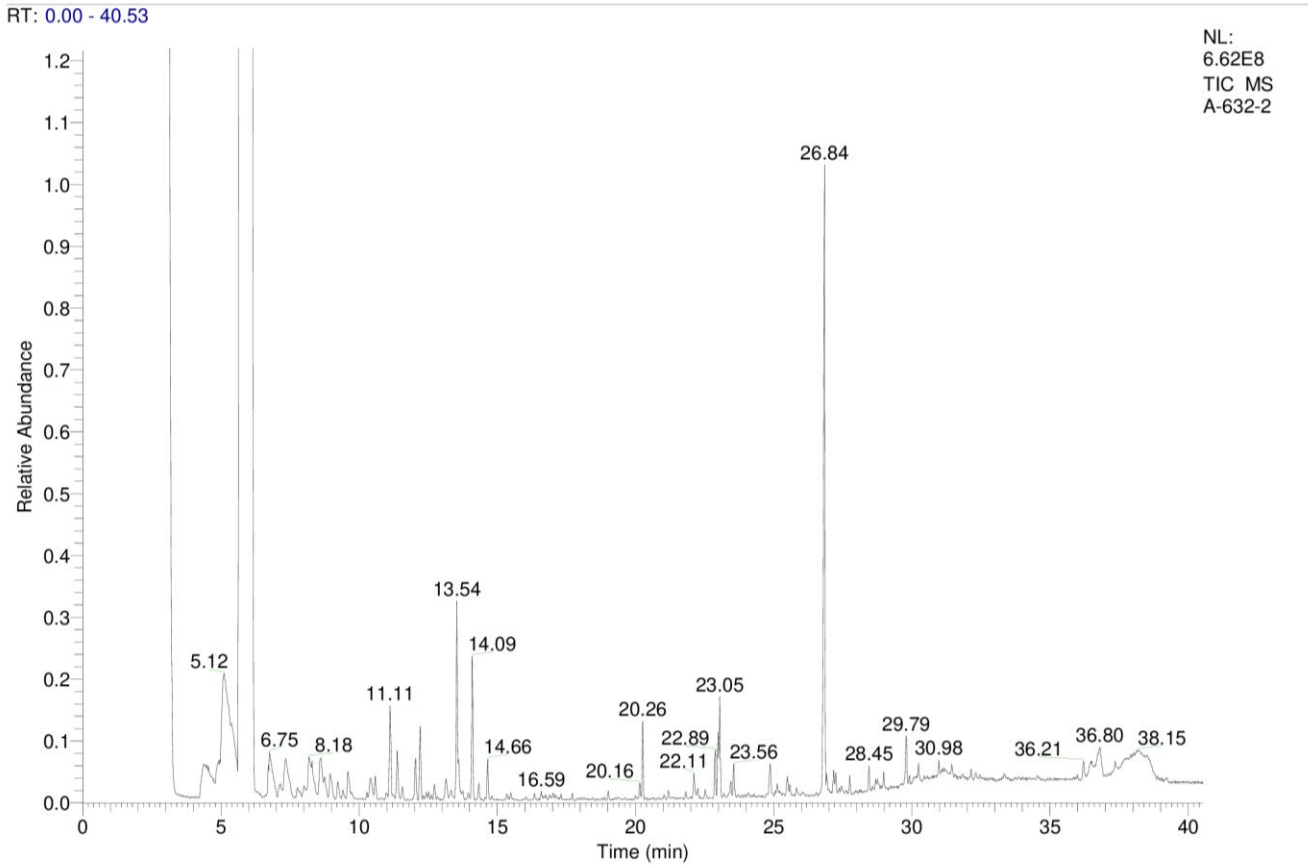


Fig. 2.GC-MS result for orange peel oil methyl ester.

There are mainly six alcohols were found in the OP oil, they are: 1-octanol, β-terpineol, trans-carveol, Nero, terpinene- 4-ol and geraniol [34]. Terpinene-4-ol is the degradation product of D-limonene and its concentration significantly improved during the stowage of the heat-treated extracts [35]. Esters have been elucidated to be most important to orange flavor. Aldehyde content, especially of decanal and octanal, is generally considered as one of the notable standards reported for characterization for OP-Oil, [36]. By concluding the analysis results with the sample, the study of the aromatic composition of OP oil consist of a total of 57 components were identified. Some of the remaining compounds were not identified by GC-MS test. There is a possibility that the component called limonene, which oxidants during the process and storage may be responsible for the formation of this compound in OP oil, which shows the volatile property.

3) Infrared spectroscopy (FTIR) analysis

The Fourier Transformed Infra-red (FTIR) analysis results, is used to identify and evaluate the functional groups, bonding type and unknown compounds (the nature of functional groups and the type of functional groups) present in the bio-diesel fuel. From (Table. 1), it specifies the FT-IR results obtained. From the available sample the results aims that the higher the extraction temperature. The FT-IR result was used to determine the degree of esterification by examining the wavelengths of Carbon bonds such as C-O and C=O bonds and the DE was found to be 58.86%. The evidence on the presence and the nature of functional groups provide stability and the reactivity of the bio-diesel-fuel as well as the efficiency conversion of the oil to bio-diesel are to be identified.

Table.1 specifies the FT-IR analysis result of raw Orange-peel oil.

Wave number (cm −1	Functional groups
3188.12–2551.22	Intermolecular hydrogen bounded O–H (alcohol)
3045.30–2921.80	C–H (alkanes methylene)
2215.40–2149.78	C ≡C (alkynes)
1628.68	C = C (alkenes)
1779.22–1717.46	C = O (ester functional group in FAME)
C = O 1474.00	C –H (alkanes)
1289.00–1076.76	C –O –C (esters)
960.90–702.28	C –H (alkenes)

From the above table, it is clear that the FT-IR spectrum for the bio-diesel were interpreted with the aid of a researcher named (Yadao - 2013) [37]. From his findings and interpretation the FT-IR table revealed that the functional groups present in bio-diesel are with characteristics bands of esters (C = O), Alkene (C = C), Alkynes (C ≡C) and Alkanes (C –H), revealing that the oil molecules contain esters functional groups. The functional groups of C = C (alkenes), C –H (alkanes) and the triple bond C ≡C (alkynes) that must be present in every good oil was noticed in the FT-IR analysis of the oil.

III. EXPERIMENTAL SETUP

A. Engine Characteristics

This present experimental investigation for the analysis of Engine performance and emission characteristics, the sample was tested on a four-stroke, single cylinder, and air cooled, DI (Direct Ignition) Kirloskar Diesel-engine powered by bio-diesel.

Retrieval Number: F9535038620/2020©BEIESP
DOI:10.35940/ijrte.F9535.059120
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The Compression Ignition (CI) Diesel-engine, coupled with a dynamometer, which is used to analyses the force while applying the load. The RPM of engine crankshaft was calculated with the help of a speed sensor. With the help of burette apparatus and stopwatch, the fuel consumption by the engine was calculated.

Also an Engine emission testing equipment is also attached with the Kirloskar Diesel-engine for finding emission characteristics of the Bio-diesel, the parameters like Carbon Monoxide (CO), Hydrocarbon Emission (HC), Oxides of Nitrogen (NOx) and smoke density were analysed. The tested sample results were recorded using AVL-DI gas analyzer for analyzing Engine Smoke measurements with Standards. For the experimental analysis of Bio-diesel, the engine was started using neat diesel for at least 30-45 mins to attain stability for taking observations for better output results. After engine conditions was stabilized. The base line data were taken as sample results based on diesel fuel. In the subsequent stages, diesel line was swapped with OP-Oil-ME blends with diesel at different volumes and respective parameters based on the results were noted.

B. Blending of Fuel

For blending of Orange-peel oil ethyl ester in diesel. Here there are 3 samples are developed for testing purpose. Initially conventional diesel-fuel and Orange Peel-Oil-Methyl Ester (OP-Oil-ME) is blended at a volume of 10% (noted as 10% of OP-Oil-ME and 90% of Diesel fuel) is poured into apparatus where it is agitated for several minutes for about 30 minutes in an ultrasonic shaker for making uniform suspension of oil and allowed to place into a magnetic stirrer for 10 min. Similarly the process continues for 2 more samples at a ratio of (volume by 20% and 30%). It should be shaken well before testing. In this experimental analysis the load was varying from 1KW to 5KW in the interval of 0.5KW load.

IV. RESULT AND DISCUSSION

The chapter details the physico-chemical properties of the bio-diesel obtained from OP-Oil shows good agreement with the ASTM standards for Bio-diesel. In order to that performance and emission characteristics of Fuel. The CI Diesel-engine was fueled with Conventional Diesel-fuel and Blended Bio-diesel fuels at different proportions at different brake powers are to be analysed. All the readings were taken twice and thrice, for taking the average value among of the three was taken for further analysis.

The performance test of the engine were evaluated using parameters like Brake Thermal Efficiency (BTE) and Specific Energy Consumption (SFC), and Emission characteristics such as Carbon Monoxide (CO), Oxides of Nitrogen (NOx), Hydro carbons (HC) and smoke Density are to be analysed. From the Physico-chemical characteristic of the bio-diesel obtained from OP oil shows decent promise with ASTM standards as depicted by Table 2. The process of Physiochemical properties are done based on ASTM Standard Methods. The introduction of Sodium Hydroxide (NaOH) in the transeterification process improves to the quality of the bio-diesel fuel. The researchers were found that, the use of catalyst called Sodium Hydroxides Catalyst gives better performance compared to any other catalysts. The results obtained from several researchers on biodiesel production is in close agreement with biodiesel required standard and by comparing it with the bio-diesels produced from neem oil [38], sunflower oil [39], soya bean oil [40], cottonseed oil [41], rapeseed oil [42], peanut oils [43], coconut oil [44], palm-kernel oil [45] and fried oil [46] requirement for bio-diesel. Thus, the bio-diesel produced could be a good alternative [47].

Table. 2. Comparison of ASTM Standards with Diesel and Bio-diesel

Properties of Fuel			
Properties	**Diesel**	**Biodiesel**	**ASTM METHODS**
Fuel Standard	ASTM D975	ASTM PS 121	
Fuel Composition	C10 - C21 HC	C12 - C22 FAME	
Kinematic Viscosity (cSt) @40 C	1.3 - 4.1	1.9 - 6.0	ASTM D 445
Density (kg/m3) @15 C	847.17	897.12	ASTM D 4052
Calorific value (kJ/Kg)			ASTM D 5863
Cetane Number	40-55	48-65	ASTM D 445
Flash Point	60-80	100-170	ASTM D 91

A. Physico Chemical Properties

Physico chemical properties of Diesel fuel, OP-Oil, OP-Oil-ME and its blends named OPOME10-D90, were evaluated using standard test facilities based on the standard methods in our college laboratory, as mentioned above.

Table. 3. The physico-chemical properties of Orange-peel oil with diesel blends

Properties	Diesel	OPO	OPOME	OPOME10-D90
Kinematic Viscosity (cSt) @40 C	3.4	12.5	4.91	5.28
Density (kg/m3) @15 C	830	945.4	849.5	855.4
Calorific Value (kJ/kg)	43200	36100	37500	35900
Cetane Number	45	39	47	49
Flash Point	67	74	65	48
Fire Point	72	85	71	53

From the Physio-Chemical test results, it is clear that the Kinematic viscosity, density, cetane number were found to increase with increase in percentage of bio-diesel. Neat OP-Oil-ME Biodiesel has lower calorific value, but having high viscosity and density than that of diesel fuel. However, calorific value decreased with increase of bio-diesel content in the blend. The Flash point and Fire point results of OP-Oil-ME and diesel blended OP-Oil-ME shows better output than that of the diesel-fuel and raw OP-Oil, which implies the usage of Diesel blended OP-Oil-ME is better for Engine combustion.

B. Engine Performance

The Engine performance of Diesel fuel, OP-Oil-ME and its blends with diesel-fuel at different volumes are tested using parameters like brake thermal efficiency and brake specific energy consumption.

1) Brake Thermal Efficiency

The performance of the Diesel-engine were evaluated using parameters like Brake Thermal Efficiency at different loads with Diesel fuel and OP-Oil-ME Blends at different proportions. The variation in Brake Thermal Efficiency (BT-Efficiency) with brake power is shown in Fig 3.

It can be observed from the graphical representation, the BT- Efficiency of all OP-Oil-ME blends with diesel at higher proportion shows better performance than that of the Conventional diesel.

At full load condition, the OP-Oil-ME is higher for different proportions than conventional diesel fuel. This is due to the fact that bio-diesel fuel obtained from OP contains around 9-12% (approx.) inbuilt oxygen content and higher cetane number than that of the diesel fuels, because from the GC-MS analysis results itself we get an idea about it.

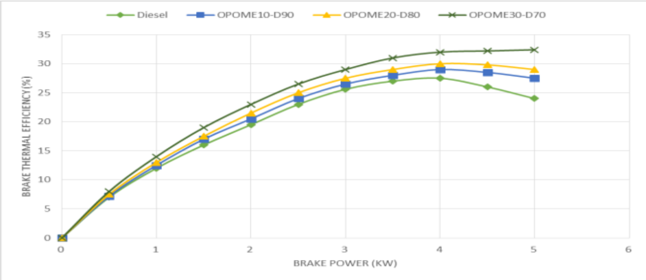


Fig. 3. Variation of BT- Efficiency with brake power at different concentrations of samples.

It consist of Limonene content, which have the Volatile property and its content is much higher in proportion. Due to this analysis results, it shows better combustion. Hence there is a notable advance in the BT- Efficiency in case of OP-Oil-ME blends. It can also be seen that, based on the increase in OP-Oil-ME concentration in blends, which increases the performance of Diesel Engine.

2) Specific Fuel Consumption (SFC)

The performance of the Diesel-engine were evaluated using parameters like Specific Fuel Consumption (SF-Consumption) at different loads with Diesel fuel and OP-Oil-ME Blends at different proportions is shown in Fig 4.

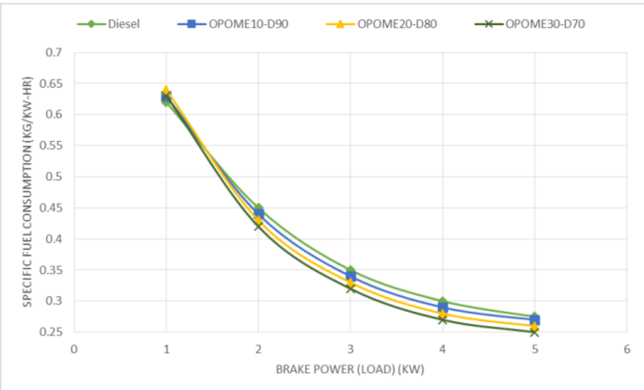


Fig. 4. Variation of SF- Consumption with brake power at different concentrations of samples

SF- Consumption reduces with the brake power for all tested fuels of diesel was better than other test fuels (Diesel, OPOME10-D90, OPOME20-D80 and OPOME30-D70). This is due to the higher calorific value of diesel [48, 49]. Specific Fuel Consumption (SFC) for OPOME10-D90 and OPOME20-D80 was higher than neat Diesel. The sample content such as in the OPOME30-D70 shows a notable variation in the efficient while comparing with the diesel blends

C. Emission Characteristics

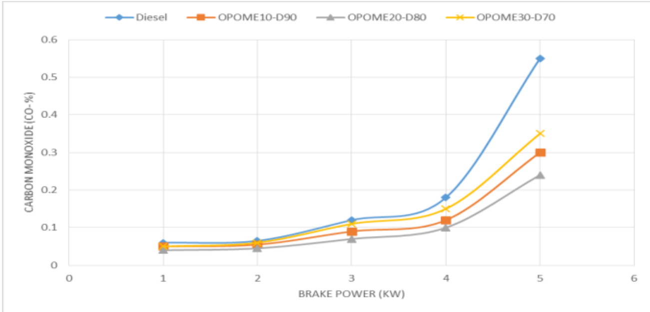
The emission characteristics of Diesel fuel, OP-Oil-ME and its blends with diesel-fuel at different volumes on AVL Smoke detector attached with CI Diesel-engine are evaluated using parameters like Carbon Monoxide (CO- Emission), Oxides of Nitrogen (NOx - Emission), Hydro carbons (HC - Emission) and smoke Density are to be analysed.

1) Carbon monoxide (CO) Emission

The variations of CO- Emission with brake power at different loads with Diesel fuel and OPOME Blends at different proportions is shown in Fig. 5

Fig.5 Variation of Carbon Monoxide (CO) emission of four samples with respect to the varying load.

The CO- Emission of OPOME bio-diesel fuels are less than



that of diesel-fuel at all brake power levels. This is because of the abundant availability of inbuilt oxygen content in OP-Oil-ME [50]. The O_2 content of OP-Oil-ME in the diesel blends also accelerates the oxidation reaction and reduces the CO- Emission [51] to a great extent. CO- Emission decreases with an increase in blend percentage of Orange-Peel-Oil bio-diesel. CO- Emission for OPOME10-D90 and OPOME20-D80 were lower than that of Diesel Fuel. OPOME30-D70 shows notable reduction in emission compared to other samples.

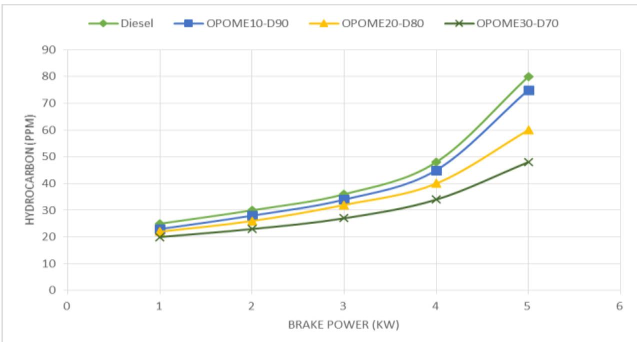
Lower viscosity of modified fuel endorses the evaporation of fuel with air and air-fuel ratio also results in improved combustion and reduces CO- Emission [52- 54]. Thus the OP-Oil-ME blended diesel fuel can used as fuel in diesel engine for eco-friendly terms.

2) Unburned hydrocarbon (HC) Emission

The variations of HC - Emission with brake power at different loads with Diesel fuel and OPOME Blends at diverse proportions is shown in Fig. 6

Fig.6 Variation of HC - Emission of four samples with respect to the varying load.

HC - Emission for the Blended Diesel fuels emission level is lower than that of conventional Diesel-fuel at the alternate



brake power. Additional oxygen content facilitates the combustion and reduce HC - Emission [50]. Addition of Orange-peel oil into bio-diesel (OPOME10-D90, OPOME20-D80 and OPOME30-D70).

From the analysis, it is found that, the HC - Emission emissions of different OPOME blends has reduced the unburned hydrocarbon emissions level as compared to neat diesel fuel. This is due to the heat sink effect of contents in modified fuels [55]. In addition, the diesel into Orange-peel oil at higher volumes or concentrations increase the evaporation tendency and lower HC - Emission [56].

3) Nitrogen oxide (NOx) Emission

The variations of NOx - Emission with brake power at diverse loads with Diesel fuel and OPOME Blends at diverse proportions is shown in Fig. 7.

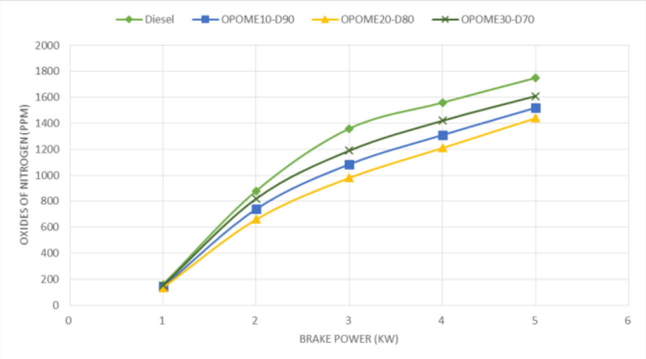


Fig.7 Variation of NOx - Emission of four samples with respect to the varying load.

The graphical representation includes the sample from diesel fuel, Blends of diesel-fuel with OPOME blends at different volumes are depicted as OPOME10-D90, OPOME20-D80 and OPOME30-D70.

NOx - Emission depend on oxygen content and mass of fuel burned. NOx - Emission from bio-diesel fuels are higher than that of conventional diesel at all brake powers. This was significantly lower for OPOME10-D90, OPOME20-D80 and OPOME30-D70 than that of Conventional diesel-fuel at all conditions, because of the inbuilt oxygen content present in biofuels is the major cause for higher NOx - Emission [49].

4) Smoke density

The variations of smoke density with brake power at different loads with Diesel fuel and OPOME Blends at different proportions is shown in Fig. 8. The graph includes the samples from conventional diesel fuel, Blends of diesel-fuel with Orange-peel oil methyl ester at different volumes are depicted as OPOME10-D90, OPOME20-D80 and OPOME30-D70.

The smoke density of the OPOME blend samples increases with an increase in the brake power at all loads. This is due to the increase in the fuel supply to maintain the constant engine power [49]. Smoke value for the samples are depicted as OPOME10-D90, OPOME20-D80 and OPOME30-D70 with conventional diesel. This is owing to the higher oxygen present in biofuel, which enhances the oxidation process [50]. Further, the smoke emissions of OPOME30-D70 is lower than that of OPOME10-D90 and OPOME20-D80 at all conditions. The blended OP-Oil-ME fuel creates the micro-explosion and atomization during combustion process, which results in the improved air–fuel mixture, lower smoke emissions [55].

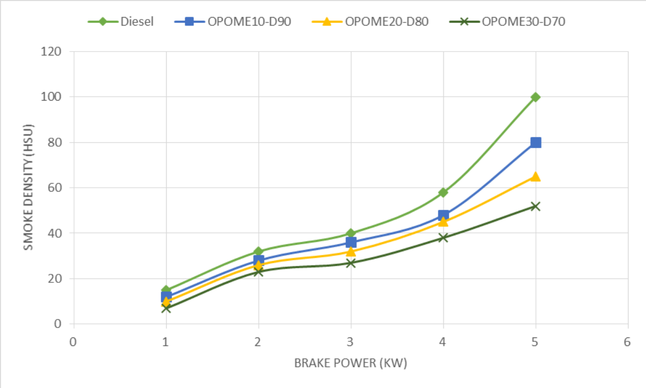


Fig.8 Variation of Nitrogen oxide (NOx) emission of four samples with respect to the varying load.

Thus we can conclude that the OPOME blended with conventional diesel-fuel at higher concentrations will increases the efficiency of engine and provides improved combustion characteristics.

V. CONCLUSION

In the contemporary experimental research of OPOME diesel blend bio-diesel, a set of comprehensive engine trials were four-stroke, single cylinder, and air cooled, DI (Direct Ignition) Kirloskar Diesel-engine fuelled with Diesel-fuel and various OP-Oil-ME blends. Several Properties such as Engine performance and emission characteristics of the engine and their comparative assessment with conventional diesel-fuel are described briefly below.

From the analysis made by the Biodiesel fuel obtained by OP is used as an alternative fuel through blending at a percentage of (30%).

The findings on the experimental analysis OPOME bio-diesel produced with Sodium Hydroxide (NaOH) as catalyst at 70 - 85 °C reaction temperature for 2-2.5 hrs. The study proves that the extracted OP-Oil is used as a sustainable feedstock for the bio-diesel production. From the primary test analysis, the oil can be used as alternative fuel for diesel engines, based on the volatile components, also the physio-chemic properties also aims to the same intentions.
Based on the available experimental results, the following conclusion was drawn:

- (BTE) at full load was found to be the better output in performance, which implies that, based on the increase in the biodiesel (OPOME) blend shows the powered diesel properties, as a result of necessarily available of good cetane rating. Full load BT- Efficiency of bio-diesel at 10% volume was bring into being to be nearly higher than that of diesel fuel, where as that of bio-diesel at 20% volume exhibited an impressive increase over baseline data of diesel. All above that bio-diesel at 30% with diesel fuel in volume exhibited an extensively notable increase over performance data of diesel.

- Hydrocarbon (HC) and Carbon Monoxide (CO) emissions for modified fuels (OPOME10-D90, OPOME20-D80 and OPOME30-D70) are lower than that of the conventional diesel fuel. The inbuilt oxygen present in biofuels is the major cause for higher NOx emissions.
- Smoke and NOx emission of the OPOME30-D70 is lower than that of OPOME10-D90 and OPOME20-D80 at all brake power.
- OP-Oil-ME diesel blends at higher concentrations will also increases the efficiency and provides improved combustion.

By concluding the experimental analysis, it is clear that, the present study on performance and emission basis. The (OP-Oil-ME) blended fuels at higher proportion (30 percent) with diesel are favorable alternative-fuels and it is appropriate for a Diesel-engine.

ACKNOWLEDGMENT

We are highly obliged to Prof. D. Rajeev, M.E., (Ph.D.) Head of the Mechanical Department, Mar Ephraem College of Engineering and technology and our Project supervisor for rendering his full support both mentally and technically by encouraging us at all times as needed. His valuable advice, constant encouragement, timely support and guidance for finishing the project work successfully. Likewise we would like to express our whole hearted thanks to Ms. A. Seema, M-Phil, Assistant Professor, Department of Chemistry, for her timely support to complete our project work. Her technical Support and valuable advices, also under her guidance we completed the Purification and further Process within the College Chemistry Lab. Teaching and Non-Teaching staff members of Mechanical Engineering Department, Chemistry Department.

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