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Biodiesel Production from Palm Kernel Oil (Elaeis Gunieensis): An Alternative Source of Renewable Energy

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Abstract
This study was design to produce biodiesel from Palm Kernel Oil (PKO) through transesterification, to characterize and evaluate the physical parameters of the fuel produced. Concerns on the increasing global warming, diminishing energy reserve and high energy cost has necessitated the search for other energy source. Biodiesel can be seen as a promising alternative which can be widely use as bio-fuels, since it can be readily produce from domestic agricultural sources such as: palm kernel oil, waste cooking oil, corn flower and animal fat. Vegetable oil (PKO) is the main raw materials for this study, this research validated the possibility of producing biodiesel from renewable vegetable sources and alcohol (methanol) in the presence of an alkaline catalyst (NaOH). The use of alcohol molar ratios is 5:1, 6:1 and 6:1 for the three experimental runs of methanol: triglycerides was evaluated in the reaction procedure, which transforms triglycerides (PKO) to methyl esters of average mean of 55.130% yield at defferent temperatures (60 degrees, 55 degrees and 65) at different reaction times (45 mins, 60 mins and 90 mins) respectively, were obtained at 1.01 % catalyst concentration. Characterization was carried out to determine the physiochemical parameters like average Viscosity of 0.5504mm/s, average specific gravity of 0.8101 degrees, average boiling point of 122 degrees, and average flash point of 137 degrees and average cloud point of 106 degrees. Apart from cloud point whose value is much higher than the acceptable standards, the values of the other four parameters are in agreement according to American Standard for Testing Materials (ASTM) required standards. These results showed that the use of bio-fuels will be very useful for many industrial applications, most especially in the transportation hydro- power sectors, since it is eco-friendly, higher combustion efficiency, biodegradability and can be applied as an alternative to petroleum-diesel.

Keywords: Biodiesel, biofuels, palm kernel oil, renewable energy.

1. Introduction

The high fossil fuel depletion, its concern to the environment and the fluctuation in crude oil prices have widens or consolidated in the search for alternative source of non-fossil fuels. Many researchers have concluded that vegetable oil hold promise as an alternative fuel for diesel engines, However, these oils cannot be used in its raw state in the internal combustion engine due to two main reasons: high viscosity and low volatility which can lead to severe engine deposit Injector coking and piston ring sticking (Leung et al; 2010). These problems can be overcome through, Trans esterification of vegetable oil using simple alcohols such as (methanol, ethanol and propanol) to produce fatty acid methyl esters (FAME), fatty acid ethyl esters (FAEE) fatty acid propyl esters (FAPE) which are also called biodiesel. Some of the methods used to achieved such conversion includes micro- emulsion, trans-esterification and pyrolysis (Knothe et al; 2005): Among these procedures, trans-esterification was found out to be the best route with least engine complication (Knothe et al; 2005, Gupta et al; 2007, Shahid and Jamal, 2011). Among other alternative fuels being evaluated as potential source of renewable energy to the present (Okwu et al. 2018; Mbachu et al. 2021; Uyanga et al. 2018; Okonkwo et al. 2021; Nwaoha et al. 2016), high-polluted diesel fuel derived from diminishing commercial resources. Biodiesel has emerged to be the best substitute for petro-diesel, not only due to its comparable calorific value but also for its several other benefits such as low toxic emissions, biodegradability, excellent lubricity, high flash point and environmental compatibility (Balat and Balat, 2010; Knothe et al, 2005). In recent times, in order to meet the future energy requirements. Biodiesel has been reported and elevated as a promising long term renewable energy source which has the potential to address net emission of carbon (iv) oxide (CO2) to the atmosphere, security concerns and constant increase in the price of petroleum products (Alamu et al; 2007a, 2007b, Balat and Bala 2010). Biodiesel is a renewable diesel substitute that can be acquired through chemical process by reacting vegetable oil or fat with an alcohol. For the past 15 years, biodiesel has improved from research stage to a large-scale production in the United States, India and many other developed coun tries. According to (Meng et al, 2009). Triglycerides use to produced biodiesel comes from various sources such as: edible oils, non-edible oils, waste used oils, animal fats and from micro-organisms. Also recycled cooking greases can also be transformed into biodiesel and be used neat or as a diesel additive in compression ignition engines.

Palm kernel oil (PKO) in combination of simple alcohol (methanol) can be used as biodiesel. Various studies has been carried out on the conversion of PKO and ethanol using catalyst to produce biodiesel or using conventional homogenous catalysts (ie sodium hydroxide or potassium hydroxide) or heterogeneous catalyst like calcium oxide. Through trans-esterification reaction (Alamu et al; 2007a, Boey et al; 2009, Huang and Chang, 2010). For centuries, men have worked hard to improve lifestyle through generation of energy. In evaluating national development and standard of living in any nation, the supply and consumption of energy is very crucial. Human energy consumption has been moderate before the industrial revolution in the late 80s. Man mostly relied on the energy from brut animal's strength to do work. Energy may be seen as one of the most important life requirements to provide good food, water, shelter and transportation. The utilization of energy can be investigated back to about 400 AD, Back then, wood was the main source of fuel for energy generation. These progressively led to other forms of generating fuel which also include nuclear power, coal energy, fossil fuel, which consists of the following: petrol, kerosene, natural gas gasoline and so many others, which account for primary energy while nuclear fission, solar energy and wood account for the secondary source of energy.

Much dependence on imported fossil fuels and regulations on the exhaust emissions of vehicles established by the Environmental Protection Agency (EPA), has increased the need for other energy sources. Alternative fuels from agricultural crops are considered as the most desirable substitute for diesel since they are sustainable and have fewer emissions than petroleum fuels.

In January 2001, the EPA finalized a rule that will require sulphur levels in diesel fuel to be reduced or minimized from 500 parts per million (ppm), to 15 ppm in the year 2006. The petroleum industries and equipment manufacturers use during the rulemaking process that the made by refinery which are necessary to meet this requirement would also dramatically reduce the lubricity of the fuel (ISA,2004). Lubricity is the characteristics in diesel product necessary to keep fuel injection pump properly lubricated, fuels which lacks lubricity can cause premature wear or malfunction (ISA, 2004). Biodiesel fuel has higher lubricity than that of fossil fuel and can be used as an additive to improve the lubricity of the diesel fuel (Howell, 1995, Knothe & Steidley 2004).

This work aimed at producing biodiesel from methyl esters of palm kernel oil, and comparing some of its properties like viscosity, flash point, specific gravity and cloud point, with the American Society for Testing Materials (ASTM) standards. The specific objectives are to: evaluate the suitability of PKO as an alternative transportation fuel; analyze the effect of biodiesel on emission characteristics of the engine; evaluate the implication of the results of this experimental study with proposed and current standards for the use of biodiesel and its blends as fuel for diesel engines. The study is highly significant as volatility of the world petroleum market is affected by constant increase in the price of fossil fuels, its increased threat to humans and environment from exhaust emissions, global warming and rapidly decreasing crude oil deposits and many other negative factors. Among different possible source of energy, this led to the quest to discover alternative source of energy that can be easily replenished. Production of bio-fuels has proven to be more suitable as an alternative energy source, since the fuel produce is very clean, contains fewer toxic hydrocarbons, environmentally friendly, biodegradable and its feedstock is readily available. This study is centred on the production of biodiesel using the vegetable oils (PKO), to characterize and determine its some physiochemical properties such as- Viscosity, Flash Point, boiling points, Specific Gravity and Cloud Point. Also, to determine the percentage yield of the biodiesel. Finally, to compare the parameters with the set standards of biodiesel by the American Standard for Testing Materials. This work is limited to production of biodiesel, using locally sourced feed stock (Palm Kernel Oil) and characterization of some physiochemical properties like viscosity, boiling point, flash point, specific gravity and cloud point.

2. Review of Literature

2.1. Further Information on Biodiesel

Biodiesel as an alternative source of fuel for diesel engines is really gaining a lot of attention in countries like United States, after reaching a considerable level of success in Europe. Biodiesel is a mono alkyl esters of long chain fatty acids which is derived from vegetable oils or animal fats which can be applied in compression- ignition engines. Its major advantages remain the facts that is one of the renewable fuels currently available, also its non-toxicity properties and biodegradability, it can also be used directly in most diesel engines with needing extensive engine modification. (D. Ayhan,2010) Opined that in addition, biodiesel fuel offers engine performance similar to the one of petroleum diesel fuel, it also has great extent biodegradable in the soil as well as flash water. Moreover, under aerobic or anaerobic conditions, 90-98% of the best part of biodiesel is mineralized within 21-28 days. Biodiesel is made up of unsaturated and saturated long chain fatty acid while alkyl esters is gotten from animal fats. According to M. A. Fazal (2011). Vegetable oils are produced from numerous oil seed crops also, almost vegetable oils have high energy content, and most of them require some procedures to ensure safety use in internal combustion engines. Some of the sources of vegetable oil includes sunflower, cottonseed oil, and soybean oil. Vegetable oil and its esters are seen to be promising alternatives fuel for diesel engines. Atadashi ;(2007), Stated that many researchers have that waste cooking oil (W C O) is seen as a better choice in biodiesel production. Talebian. (2013), Opined that biodiesel production cost might be considerably reduced up to 60-90% when waste cooking oil was used during the production process. According to Yaakob (2013), before, waste vegetable oil is being used, it has to be filtered to remove dirt and other unwanted particles, charred food and other non- materials usually found in it. Water is also removed because its presence causes the triglycerides to hydrolyze to give salts of the fatty acids instead of its primary aim which is to undergo Trans esterification to give biodiesel. This is usually accompanied by heating the filtered oil to approximately 120 degrees. At this temperature dissolved or suspended water will boil off. When the water boils, it spatters (Chemists refers to it as bumping). To prevent injuries, this process should be carried out in a sufficiently large container (at most two-third full), which can be closed but not sealed. Recently, tremendous efforts are being made to develop feedstock such as microalgae clearly provides several advantages compared to plant oils, which includes high yield production of biomass when compared to that of land plants, and a good number of species can be up to about 20-50% triglycerides, whereas less fertile agricultural land is sufficient to achieve biomass(Demirbas ; 2011), Further, stated that microalgae oil has the potential or is capable of producing higher biodiesel yields with about 25% reduction in the production cost.

2.2. Renewable Energy

Renewable energy can be defined as any energy source that is gotten directly or indirectly from solar energy. Considering that the major composition of greenhouse gases (G H Gs) is carbon iv oxide, this is a serious global concern on how to reduce carbon emissions. In this regard, different policies should be applied to combat carbon emissions, such as: Enhancing renewable energy deployment; encouraging technological innovations; use of support mechanisms like: feed-in tariffs; renewable portfolio standards, and tax policies, all these are applied by the government to enhance development of renewable energy alongside with implementing energy use efficiency for preserving energy. The importance or need of an alternative energy source comes together with climate change challenges associated with the excessive use of fossil fuels. There are three major primary factors which motivates the growth of renewable energy technologies, namely: Energy security, economic impacts and carbon iv oxide emission reduction. However, the alternative energy can be referred to as any form of energy other than the conventional sources of energy, including hydropower. Presently, now the focus has been on renewable energy sources. According to (I E A, 2012d), it refers to the significant global trends that should be characterized the deployment of renewable technologies over the medium term. Firstly, as renewable energy technology scaled up, from total global supply of 1454 gigawatts (G W) in the year 2011 to 2167 GW in 2017, which should also spread out geographically. Secondly, in the more recent years of high fossil fuel, energy consumption has caused renewable technologies to become increasingly competitive on a cost basis with their alternative in a number of countries and circumstances. According to I E A calculations, wind is the most competitive type of renewable energy technology among other options, if local conditions such as financing, CO2 emissions level and fossil fuel prices has proven to be favorable (O E C D,2010). In the field of clean technologies, there are two major concepts of energy technologies, namely; energy supply technologies, which is also known as an alternative source of renewable energy (examples are solar power and wind), and energy efficiency technologies, it can also be those technologies which are hired to enhance energy use efficiency (example are combined heat and power, virtual power plants and smart meters). It should be noted that transforming the energy sector and replacing conventional energy with renewable is evolutionary associated with technological change and forming markets. Jacobson and Bergek (2004) Opined that the transforming process for certain forms of renewable energy, such as wind and solar will takes place after the year 2020, even if the growth rate of consumption is on the increase over the next decade. However, renewable energy markets are not easily formed due to high cost, disadvantages and the subsidizing of fossil fuels.

2.3. Transesterification Process

Biodiesel is usually produced through trans esterification and this process involves reaction between triglycerides and alcohol in the presence of a catalyst to produce esters and glycerol. This is, the most appropriate method used in the conversion of vegetable oils into biodiesel, however, its believed to be the most popular reaction used in other to reduce its viscosity. The molecular weight of a typical ester is roughly one-third that of typical oil molecule and therefore has a much lower viscosity. To complete the trans esterification reaction stoichiometrically, 3:1 ratio of glycerides to alcohol will be required Atadashi, (2007). Stated that after transesterification, the ester can be separated from glycerol by simple gravitational sedimentation, reasons behind the washing is to remove any traces of alkali. Biodiesel is conventionally purified using water and dry washing technologies. Water could get rid of the remaining sodium salts and soap formation, this can take place as a result of their water solubility(they are readily soluble in water), Hayyan (2010), is of the opinion that even though water washing method is effective, but there are problems associated with this method, such as: increase in the production time and cost, difficulty in extracting the biodiesel from water, Apart from the above mentioned issues, using water to purify crude biodiesel could result in increase in wastewater discharges, thereby causing severe environmental effects due to high PH values, high content of biological oxygen demand and chemical oxygen demand. Atadashi,(2012). Suggested that to overcome these problems, dry washing techniques by means of magnesol powder, ion exchange resins and acid clay and so on was introduced to substitute the water washing technology. Though, dry washing method is used for commercial process, yet its chemistry is not fully known. Atadashi (2011), opined that, due to the importance of glycerol in biodiesel production, it is usually refined before it can be used for conventional applications in food, cosmetics and pharmaceutical industries. Recently, glycerol is used in the following ways as: carbon feedstock in surfactants, polymers, lubricants and intermediates, feed for animals. Alkaline catalysts such as NaOH and KOH are most commonly used in trans esterification, owing to the fact that their reaction is much faster than an acid-catalyzed reaction but when high free fatty acid (FFA), raw materials like fryer grease is used, the reaction is then partially driven to saponification which partially consume catalyst and produce soap. Soap resulting from saponification creates difficulty in separating the by-product, glycerol from biodiesel which easily reduces the ester yield. Although, acid-catalyzed trans esterification does not encounter this problem, it requires a longer reaction time, higher reaction temperature and corrosion-tolerance reactor. However, the use of two steps acid/alkaline catalyzed trans esterification process could be more suitable to produce biodiesel from high FFA feedstock like fryer grease.

2.4. Historical Background of Biodiesel

Biofuels are fuels derived from biomass, Biomass in turn is a natural matter collected from plants or animals' sources. Feedstock's which are very essential in the utilization of biofuels are usually classified into three categories such as: sugar and starchy crops, cellulosic biomass and oil producing trees. Due to the requirement in discovering of alternative source of energy, this feedstock is used in the production of biofuels, especially methanol as gasoline blends or substitutes. The general characteristics of these oils are the fact that they can be easily converted into fatty acids and glycerin.

2.5. Properties of Vegetable Oils (Coconut and Palm Kernel)

Biodiesel fuel molecules are saturated and unbranched hydrocarbon molecules with carbon chain length ranging from 12 to 18, while that of vegetable oil molecules are triglycerides generally with non- branched chains of different length and different degrees of saturation. Vegetable oils largely contains triglycerides of about (90-98%) and small amount of mono- and di-glycerides. Triglycerides are esters of three fatty acids attached to glycerol molecules. Both biodiesel oil and vegetable oil are biodegradable, non- toxic and clean fuels. Vegetable oils and their substituents as diesel engine fuels can lead to substantial reductions in carbon monoxide, sulfur polycyclic aromatic hydrocarbons, smoke and particulate emissions. A number of vegetable oils such as rice bran oil, cottonseed oil rape seed oil, sunflower oil and jatropha oil have been investigated as fuel in engines (Vyas et al; 2009, Antony et al; 2012, Gui et al; 2008, Dorado, 2007). Studies shows that over short period of time, neat vegetable oil perform satisfactorily in unmodified diesel engines. Vegetable oils have high viscosity due to large molecular structures (Anastopoulos et al; 2009). The viscosity of liquid fuels affects the cold flow properties as well as spray atomization, vaporization and air/fuel mixture formation. Higher viscosity also has an adverse effect on the combustion of vegetable oils in existing diesel engines, fuel pumps and injectors, also, temperature changes has a great impact in the vegetable oil viscosity. It has been reported that the viscosity of fats and Oils decreases almost at the initial temperature. The flash point of vegetable oil is usually very high (above 180 degree C), and the range of heating values are within the range of 36-40MJ/Kg as compared to diesel fuels which has about 42-45MJ/Kg. The presence of chemically bonded oxygen in vegetable oils lowers their heating values by about 10%. The octane (cetane) numbers are in the range of 30-45. Vegetable oils have comparable energy density, heat of vaporization, cetane number and stoichiometric air ratio the same as that of mineral diesel, also vegetable oil can be combined with conventional diesel in any proportion and blends have been used successfully in diesel engines. Biodiesel fueled engine emits lower polluting species without need for additional emission control equipment. The characteristics of biodiesel are almost as the same as diesel fuels and this attribute makes biodiesel a better alternative to replace fossil fuel. Finally, the conversion of triglycerides into methyl or ethyl esters through the Trans esterification process reduces the molecular weight by one-third to that of glycerides and also reduces the viscosity by a factor of about eight, which in turn increases the volatility marginally. These esters contain 10-11% of oxygen by weight, which has the tendency to encourage more combustion than hydrocarbon base diesel fuels in an engine. Canakci and Gerpen (1998), Opined that biodiesel has lower volumetric heating values of about 12% than diesel fuels but on the other hand, its flash point is usually high.

3.6. Fuel Formulating Techniques

The alternative diesel fuels have to be technically and environmentally acceptable and also economically viable. Based on these criteria, triglycerides (vegetable oil/ animal fats) and their derivatives shall be considered as viable alternatives to biofuels. One major challenge associated with application of biodiesel oil in diesel engines is their higher kinematic viscosity due to higher or heavier triglycerides and phospholipids, and these result in difficulties during pumping and atomization, carbon deposits on the piston, ring-sticking, cylinder head, ring grooves and so on. Straight vegetable oils are not really suitable as engine fuels; hence, it has to be modified to bring their combustion related properties, especially viscosity closer to mineral diesel. Pyrolysis or heating, dilution or blending, micro-emulsification and trans esterification are some well-known techniques available which can be used to overcome viscosity related issues associated with the use of vegetable oil in diesel engines, it also aids them to be very compatible to the hydrocarbon-based diesel fuels.

3.7. Manufacturing of Biodiesel

About 80% of world energy production gotten from carbonaceous fuels are petroleum, coal and biomasses. Bio-oils are seen as liquid fuels derived from biomass, such as forestry and agricultural by-products by thermochemical or biochemical processes (Demirbas et al 2009). Bioethanol is a product of raw materials like straw, wood or corn. However, biodiesel is also another important renewable fuel which can be acquired through transeterification glycerides with methanol. Glycerides can be found in Oleaginous products like cooking oil, waste greases, rapeseed oil, pork hard, biomass from algae. (Girio et al 2017), Opined that oleaginous crops are the dominant feedstock used in the production of biodiesel. Therefore, materials used for biodiesel production must however, be checked out for impurities in order to improve the final product. According the (De Rossi et al 2016). In some countries like China, Calabria and Italy. Jatropha seed oil is gaining increasing importance as a potential feedstock for producing biodiesel. (Bagnatoet;al 2017), States that biodiesel a promising renewable fuel which significantly reduces CO2 emissions, comparatively with fossil fuels. Notably the production of biodiesel is on increase globally for example between the period of 2000-2012, the daily production increased from 15 to 450 thousand barrels, in the year 2015 was 31000 ML and, estimate for the year 2020 point a production of about 110,000 ML. (Okeye et al 2016), Opined that biodiesel cost is by about 0.89 per volume unit, when it is been compared with the cost of fossil fuel and the high production cost can be associated with the high energetic consumption. The life cycle from the plant to biodiesel production, usually consist of intricate cycle of multiple steps such as: Crop production, harvesting, seed cleaning and drying, oil and meal production, tran's esterification using extracted oil. This transeterifications reaction is an equilibrium reaction which usually occurs in several phases in the presence of a catalyst, while its final product will be a blend (mixture). Integrating a fraction of the original non-purified triglycerides, intermediary products, glycerol, unreacted alcohol, a catalyzer and even foams formed through saponification in an aqueous medium. However, biodiesel is an alternative that is renewable in such that its primary raw material has a sustainable origin, according to (Yosimoto, 2001), bio-diesel can be defined as mono alkyl esters of long chain fatty acids from renewable feedstock such as animal fats or vegetable oil, which can be applied in compression ignition (C I) engines.

3.8. Biodiesel Characterization

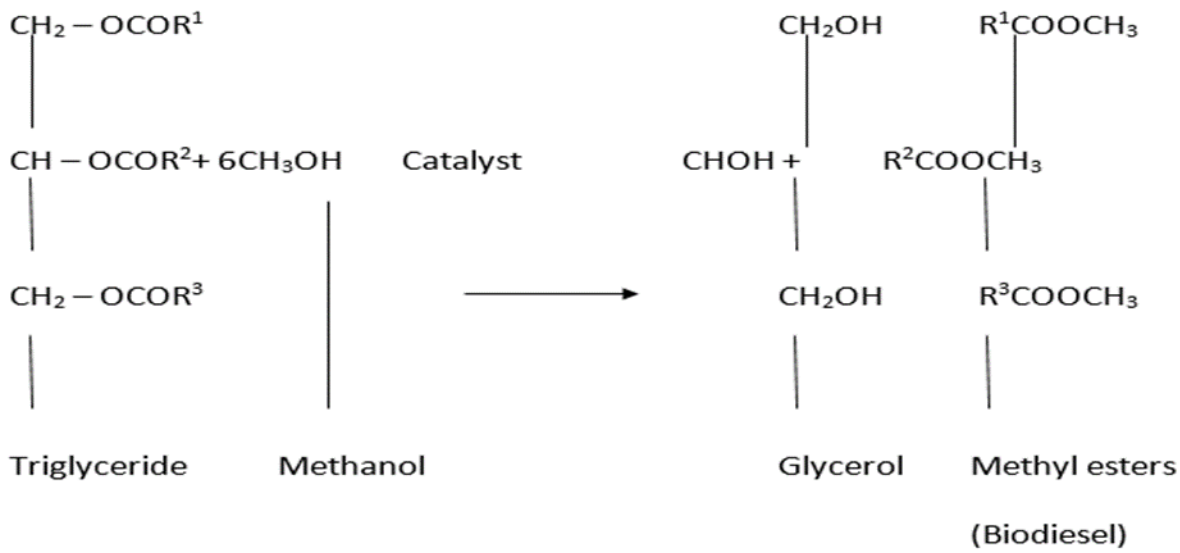
Biodiesel is characterized by determining its properties like; viscosity, density, flash point, specific gravity cloud point, through various experiments using ASTM standards, for example, ASTM adopted for pour point was D97, while flashpoint is D93, these standards was used to compare the properties. Viscosity of biodiesel, this is the main property which play important role in the combustion of fuel, viscosity is the measure of internal resistance present in each real fluid, causing the fluid to oppose the dynamic variation of its motion and therefore, restricting its tendency to flow (Latini, 2006), too low viscosity can lead to excessive internal pump leakage, the effect of viscosity is critical at low speed or light load condition (Babu et al, 2012). Temperature greatly affect viscosity, many problems of high viscosity are mainly noticed under low ambient temperature and cold star engine condition (Amit, 2009). Flash point is used as a mechanism to limit the level of unreacted alcohol, present in the finished biodiesel. Flash point is the minimum temperature at which fuel gives of sufficient vapors which can be mixed with air to cause an ignition momentarily. (Anit, 2009), determination of flash point is needed for all type of biodiesel, in other to classify it as non-hazardous under National Fire Protection Association (NFPA), Code (NERL,2009). Flash point is important in connection with legal requirements and for safety precautions involved in fuel handling and storage. Mass density; this directly affects fuel performance, such as cetane number, heating value and viscosity which are strongly connected to mass density (Barabas 2011).Specific Gravity, measuring of specific gravity is an accepted field test used to determine the quality of diesel fuel, it gives signals when there is presence of impurities or contaminants in diesel (biodiesel), However, specific gravity varies with changes in fatty acids compositions and glycerin content, since fatty acid content dictates specific glycerin, also it was observed that a denser vegetable oils is likely to produce a denser biodiesel fuel.

Cetane Number: This measures the point at which fuel ignites when it is under compression, the higher the cetane number, the greater the ease of ignition, most petrol-diesel fuels have a cetane numbers ranging from 46-60 and meets the specifications for ASTM D6751. Cloud point and Pour point tests are relatively quick and easy, they are used to estimate the cold filter plugging points, which is actually the temperature above which fuel can be acceptable for usage, fuel might work, if its temperature falls below the cloud point, but definitely biofuel cannot at temperature below the pour point (after it has gelled). Cloud point is seen as the minimum temperature at which the first crystals formation occurs while Pour point is the lowest temperature in which a liquid loses its flow characteristics. The temperature at which cloud start to form in biodiesel is known as the cloud point. Finally, cloud point and pour point properties are significantly or mainly for fuels which is to be used in the cold regions. Cloud point is the lowest temperature at which oil becomes cloudy and the initial formation of crystal are observed as the oil began to cooled gradually under standard conditions.

3.9. Biodiesel as an Alternative Energy Source

Biodiesel is gotten by esterification process using either Potassium Hydroxide (KOH) or Sodium Hydroxide (NaOH) as catalysts, while both coconut oil, palm kernel oil and alcohol are the major raw materials. The constituents of biodiesel include palm kernel oil about (60-65 %), coconut oil between (20-25%) and methanol about (5-10 %) while NaOH/KOH is in trace amount and other impurities. During the period of production, glycerin and other unwanted compounds produced alongside the product (biodiesel) is removed by further treatment with other solid catalysts such as cocoa pod ash and so on. Cleaning to remove other impurities and moisture is necessary before biodiesel can be ready for use as an energy fuel. The world is experiencing melting of ice caps, rising in temperatures and increasing of natural calamities and scientists are of the opinion that one of the major factors for this drastic increase in climate change is the excessive usage of fossil fuels and the consequent release of greenhouse gases into the depleting atmosphere. According to U.S. Department of Energy (2018), biofuels like methanol or ethanol produces up to 48% less carbon dioxide than conventional gasoline, however, the use of biodiesel produces only about one fourth the amount of CO2 which the conventional diesel releases, making it more environmentally friendly option as compared to that of fossil fuels. Unlike its non-renewable counterpart, biofuels can also be a continuous process without getting depleted, since we can always plant more crops which can processed into biofuels. Furthermore, continued interest in the scientific community has resulted in higher productivity rates of vegetable oil crops, and thereby addressing some of the deforestation issues associated with biofuels production. With palm oil having the highest crop yield among other vegetable oil options. It is believed to be the most economical benefits of biodiesel, the oil palm tree has a life cycle of about 30 years or more, which makes it better as a high carbon capture value, absorbing CO2 that is released into the atmosphere. Therefore, in the nearest future when fossil fuels might have been exhausted, perhaps we might see biodiesel as the safest renewable alternative source of energy.

3.10. Chemical Reaction



3.11. Biodiesel Purification Procedure

Membrane Separation Method The separation of solution component via membrane can be achieved by restricting the passing of unwanted materials through a semi-permeable barrier in a selective manner. (Alicieo, 2002), Opined that transportation using membrane is affected by diffusion of individual molecules, temperature or pressure gradient and concentration difference. Membranes are of two different classes' organic and inorganic membranes. Inorganic membranes such as ceramic membranes have great potentials towards aiding purification processes. Inorganic membranes (AL2O3, TiO2, ZrO2, SiC) are presently given much attention for been superior to organic membranes in terms of increased resistance fouling, long lifetime, mechanical, thermal and chemical stability membrane technology has been playing essential role in the refining of various products. Consequently, hollow fibre membrane extraction (poly sulfone) was used to remove impurities in biodiesel. According to (He et al; 2006). The crude biodiesel was passed over heated sodium sulfate and then well filtered. This method is believed to be successfully decreased the loss of yield during the refining process and prevented formation of emulsion during the washing step. Further biodiesel purity of about 90% was obtain and the physicochemical properties met the ASTM Standards, (Saleh et al; 2010). Stated that membrane technique can be employed in refining crude biodiesel without involving water washing process. The membrane systems could enhance treatment of effluents, and valuable product recovery.

3. Materials and Methods

3.1. Materials: The materials used for biodiesel produced by trans-esterification oil as follows: Palm Kernel Oil (PKO), alcohol (Methanol), catalyst (Sodium Hydroxide). Equipment used are: Reactor (Mixer), Viscometer, weighing device, heater (burnsen burner), Thermometer, Spatula, filter paper, retort stand, separating funnel, conical flask, beakers, measuring cylinders, thermal-hydrometer, baskeyl setapoint, measuring tape and PET bottles for storage.

3.2. Methods: Steps involved in production process: Purchasing of all the required feedstock for this study; filtration of both PKO to remove impurities, weighing of all the raw materials, mixing of PKO, mixing of alcohol and the catalyst, pouring the mixed alcohol and catalyst into the oils, pouring all the mixtures into the reactor/industrial mixer, reactions of the mixtures to give product, separation of biodiesel and glycerin, removal of un-reacted alcohol, rethyl ester washing and biodiesel drying.

3.3. Sample Preparation

Two litres of palm kernel oil were bought at Ajasa chemical market in Anambra State. The alcohol (methanol 99% pure) was of analytical grade with boiling 64.7 degrees, bought at bridge head Onistsha, Anambra State. The catalyst sodium hydroxide was also of analytical grade obtained from Obioha and sons Chemicals Onitsha Anambra State. By stoichiometric equation of this process, 1 mole of PKO is required to react with 6 moles of alcohol (methanol), in the presence of a catalyst to produce 3 moles of biodiesel and I mole of glycerin (Chitra et al, 2005). 20 grams of PKO were used for the transesterification process. The first run reaction temperature of 60 degrees was selected and the reaction time was 45 minutes,

3.4. Experimental Procedure

Filtered clean palm kernel oil was heated near boiling up to a temperature of 55 °C to evaporate any water present, also it is important not to overheat the oil above 65 °C, in order to avoid denaturation of the oil. The heated oil 20 liters was measured and transfer into the industrial mixer. Sodium methoxide was prepared in PET container, adding 5.6grams of NaOH to 4 litres of methanol (added first), shaking was done for about 15 minutes for uniform mixing to be achieved. Already mixed sodium methoxide was carefully poured into the PKO, the mixer was tightly secured and agitation was done. The trans-esterification reaction is assumed immediately all the consumables were mixed together. The agitation in the mixing machine was maintained for at least 45 minutes in the first case. A second set up was carried out for about 80 minutes. The mixture was poured into the separator held standing by a retort stand for settling, its tap was screwed tightly. Phase separation commenced after about 15 minutes, but the mixture is allowed to settle for 72 hours to ensure proper separation.

3.5. Separation of Biodiesel from By-product

The product was then allowed to settle down overnight. Two distinct liquid phases: crude ester phase at the top and glycerol phase at the bottom would be produced in a successful trans-esterification reaction. There are a few methods to separate these 2 layers, including using the separating funnel.

3.6. Purification of Biodiesel by Washing

The top ester phase (biodiesel) was separated from the bottom glycerol phase by transferring to a clean 1000 ml conical flask. The biodiesel was then purified by washing with hot distilled water to remove all the residual by-products like excess alcohol, excess catalysts, soap and glycerin. The volume of distilled water added was approximately 15 % of the biodiesel volume. This step was divided into two parts in order to verify the importance purification of raw biodiesel by water.

4. Results and Discussion

Table 4.1: Results for the Transesterification Experiment.

Experimental Conditions	First Run	Second Run	Third Run	Average
Reaction Temperature	60º C	55º C	65 ºC	60 ºC
Reaction Time	45 mins	60 mins	90 mins	65 mins
PKO Quantity	20 g	20 g	20 g	20 g
Methanol Quantity	100 g	120 g	120 g	113.33 g
Biodiesel Obtained	55.250 %	55.430 %	54.703 %	55.130 %
Glycerol Obtained	60 g	70.45 g	73.10 g	67.85 g
Losses	5.41 g	4.71 g	3.24 g	4.45 g

Table 2: Fuel Characterization Results for (PKO) Biodiesel.

Fuel Characteristics	First Run	Second Run	Third Run	Average Values	ASTM D6751	EN 4214
Viscosity mm2/s	0.5436	0.5661	0.5417	0.5504	1.9-6.0	3.5-5.0
Specific Gravity ºC	0.8087	0.8109	0.8107	0.8101	0.802	0.8-0.90
Boiling Point ºC	124	121	120	122	315-350	---------
Flash Point ºC	134	140	136	137	100-170	>120
Cloud Point ºC	101	107	109	106	14.25	----------

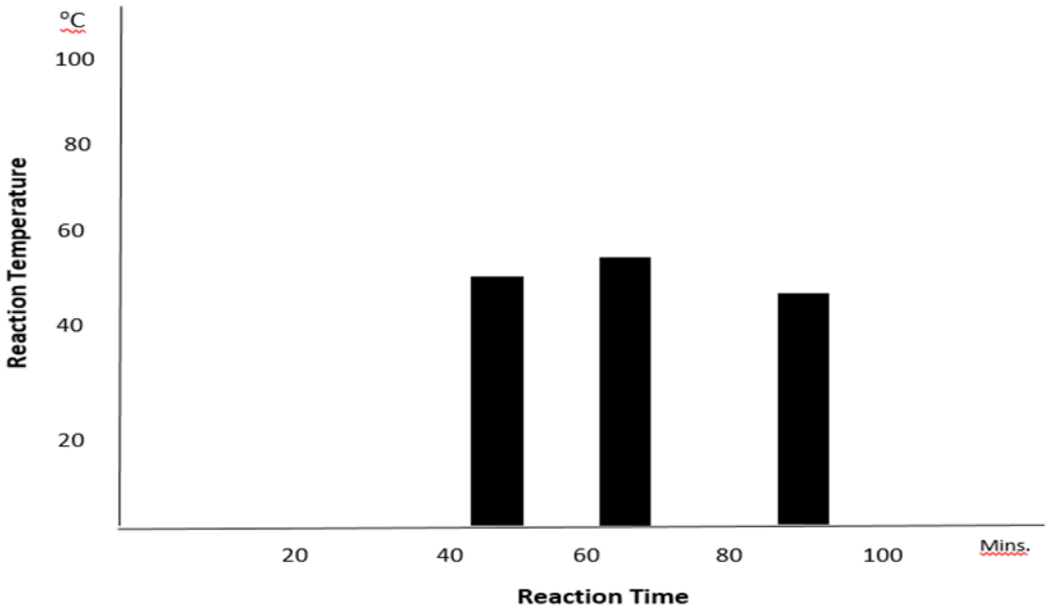


fig. 1: Effect of Reaction Time and Temperature

5. Discussion of Results

5.1. Fuel Characterization

The laboratory scale of (PKO) biodiesel produced was characterized to determine some basic physiochemical properties. The results obtained yielded 55.250% for the first run, 55.430% for the second run and 54.703% for the third run, these values obtained showed its capabilities to enhance biodiesel fluidity in diesel engines. The average viscosity for the experiment is 0.5504mm2/s, average specific gravity obtained was 0.8101 .C, the average boiling point obtained was 122.C, and average flash point obtained was 127C. And finally, the average cloud point obtained was 106. C, from the values obtained above, it was concluded that both viscosity, specific gravity, boiling point and flash point are within the limit of ASTM specification for biodiesel engine fuel, the cloud point was very high, more than 15% higher than the acceptable International Standards. However, the four respective values obtained in this work compared favourably with the previous results in the literature (Abigor et al; 2000). Finally, these properties were also checked and found that they fulfilled the requirement of the standard method specification as well as (ASTM D6751 and EN 4214 methods). Hossain et al (2009a), also reported the same results.

5.2. Effect of Reaction Time

Results obtained from this work showed that the biodiesel yield is dependent on the reaction time and temperature. At the lower time of 60 minutes, the biodiesel yield was 55.430% at temperature of 55. C, for the second run, thus the highest yield was obtained at this second run, followed by the first run whose yield was 55.250% at 60.C in 45 minutes, while the third run has the lowest biodiesel yield of 54,703% at 65, C in 90 minutes. From the above results it was concluded that increased in reaction temperature and time affect biodiesel production yield. As represented in Tables 1-2 and Figure 1.

Conclusion

Need for constant supply of fossil- fuel is of paramount importance over the years, due to rapid industrialization going on all over the globe. Depletion of crude oil deposits can lead to the scarcity of petroleum fuels in the nearest future. Increasing negative environmental impact caused by the toxic emission from fossil- fuels is also increasing. Therefore, production of biodiesel from domestic natural process might be one of the solutions to this problem, since its feedstock can be sourced locally and readily available. In this study, transesterification process yielded an average of 55.130% biodiesel, average yield of glycerol was 77.58 g and average mean of 4.27 g of total reacting mass could not be accounted for, these losses is due to some unreacted alcohol, residual catalyst and emulsion removed during the washing stage of the production process. (Alamu et al; 2007b). The comprehensive details of the results is presented in tables above. Economic values showed positive results. Apart from cloud point value that was very high, every other physiochemical property of this biodiesel was found to be within the American Standard for Testing Materials (ASTM) acceptable limit. Therefore, there will be no need for engine modification when this biodiesel is used or blended with diesel fuel.

Recommentation and Suggestion for Future Studies

I strongly the use of activated carbon as a catalyst by other researchers who will be producing biodiesel with palm kernel oil. When producing biodiesel, one should ensure that the alcohol used is close to 100%. Future studies are needed to carry out evaluation on other physiochemical and chemical properties such as determination of fatty acids contents of PKO and CNO, Cetane number, density, refractive index, phosphorous content present in biodiesel fuel. However, researches could be conducted using other types of biodiesel oils like tallow, waste cooking oil, corn oil which are readily available in Nigeria.

Contribution To Knowledge

The study has revealed that the yield of biodiesel from a single feedstock is lower (PKO) compared to the yield of the feedstock when used in combination of two or more like (coconut oil and palm kernel oil).

Acknowledgement

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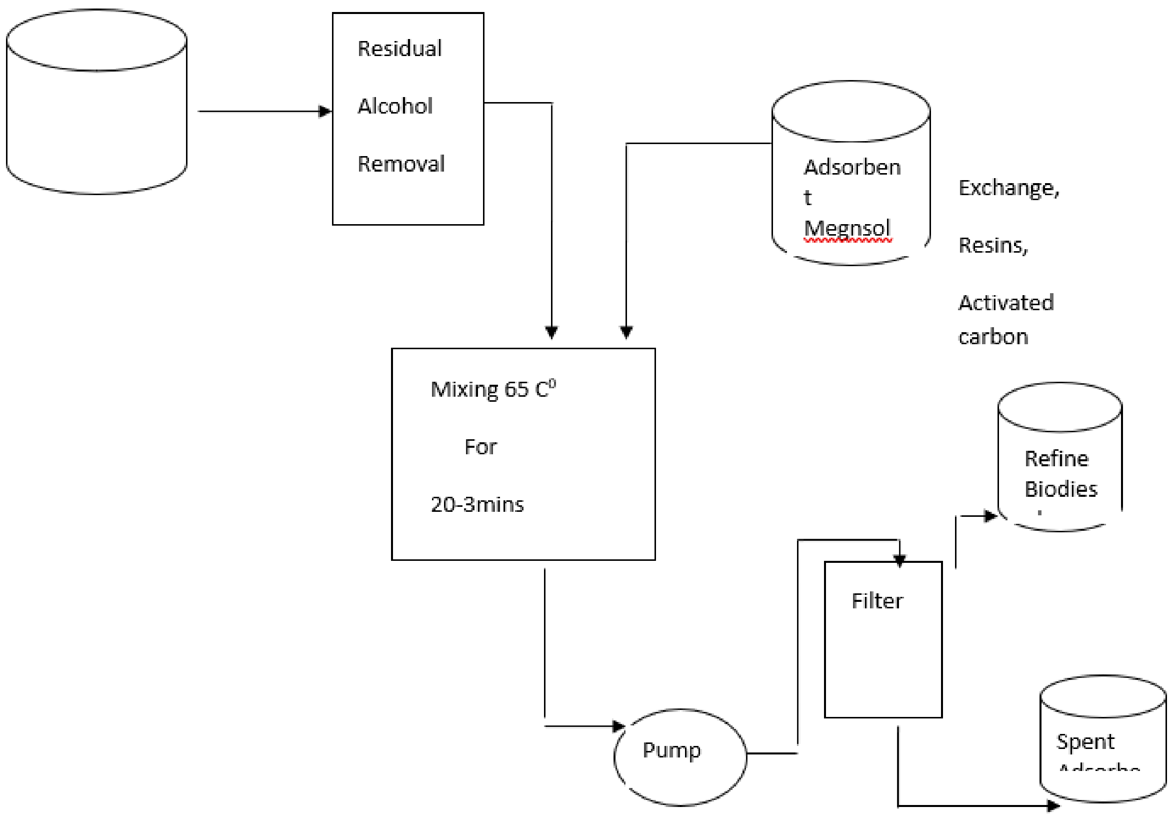
Appendix



Schematic Diagram of Biod, Dry Washing Technology.

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