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A Review of Biodiesel Production Process from Waste Cooking Oil

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Abstract - The need for safety and environmentally-friendly alternative energy sources has growth in now days due to the awareness of the negative impacts of fossil fuels on the atmosphere and the regular increase in crude oil prices. Its specific characteristics such as a substantial decrease in emissions of green house gas, non-sulfur emissions and non-particulate contaminants, low toxicity and biodegradability. So biodiesels proved the best substitute for diesel. This article explores the chemical and physical substances of Esterification, waste cooking oil, Transesterification and biodiesel production by different methods and catalysts as yet mentioned. This article discusses pretreatment and waste cooking oil. The factors which affect the process parameters mentioned are investigated and the emphasis is on the quantitative and qualitative scope of the alcohol / oil relationship, the response-temperature and the catalyst. The optimal conditions are investigated and Biodiesel and petroleum diesel which are exhausted emissions also comparison is made.

Keywords - Transesterification, Esterification, Biodiesel, Free Fatty Acid, Fatty Acid Methyl Ester, Waste Cooking Oil, Waste Frying Oil, Waste Vegetable Oil

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INTRODUCTION

Several issues such as energy efficiency, environmental trouble and rising fuel prices were faced in the 21st Century. Conventional fuel pollution including SO2, CO2, oil, particulate matter and other gases have been known to pollute the environment. As a result, more work has begun on alternative energies and renewable energy sources [1-6]. However, the world's electricity demand is rising ever since power sources have declined. The global transport sector has inflated fuel consumption considerably to 61.5% of total fuel consumption, chiefly in the past decennium [7]. The world's fuel supply is only projected in the next 46 years. Therefore, there is growing interest in research for an efficient oil diesel substitute [8]. Today, India manufactures just 30 % of the entirely consumption of petrol fuels and the remaining 70% is carried, costing approximately Rs. 80, 00 million annually. It is obviously possible to save an additional Rs 40 million annually by adding 5% of biodiesel fuel to the current fuel [9].

Its advantages on oil/ petroleum diesels including a substantial reduction in, non-sulfur emissions, greenhouse gas emissions and nonparticulate matter pollution, low harmfulness, biodegradable and renewable. Biodiesel has become an equation of the 1990s with the consequences of global warming starting to gain political attention. In addition, the amount of energy consumed in biodiesel is around 90% higher than that used for its production [5]. Biodiesel blended to ordinary diesel can be used in certain amounts to power any conventional compression ignition engine, which does not need engine modifications.[8,10] Because of benefits such as abundant natural resources, low costs and the potential for greenhouse gas reduction, biodiesel now has a global penetration in numerous supporting applications , in particular, in developing countries such as the USA and France. It is also estimated that if substances like waste-cooking oil and other bio-wastes are used as natural material for the production of biodiesel, India will add to 41.14% of its whole consumption of diesel fuel [9].

Different processes can be used to process biodiesel. There are follows as

1. Clear use or combining of diesel fuel,

2. Diesel fuel micro-emulsions,

3. Cracking vegetable oils thermally and

4. Transesterification, Transesterification is focused in this study.

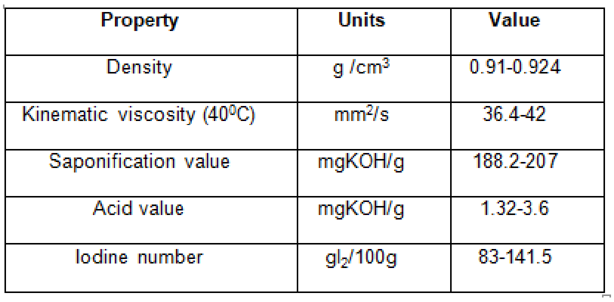
Transesterification is the practically familiar process in which alcohol is replaced with an ester alkylic class [10,16]. Biodiesel might be characterized as fatty acid methyl esters (FAME) extracted from transesterification by alcohol and suitable catalyst of Triglycerides (animal fats or vegetable oils) [7, 10, 12]. For functioning a diesel engine, biodiesel is utilized in proportion as a petroleum fuel constituent blend, since there are engine issues with the use of tidy biodiesel [16]. The main performance metrics were evaluated: production rate, yield, product quality. Biodiesel can be emanate from different sources of triglyceride, including vegetable, waste oils or non edible, animal fats (mostly eatable fats or waste fats) and microalgae oil [7, 11]. The cultures that are known for biodiesel include maize, , palm, olive, sunflower, soybeans, rape, canola and animal lipids, peanut soils (i.e. butter) [7]. Economic viability for biodiesel depends on low feed supplies.[18] The main effect for large-scale biodiesel applications comparison to oil diesel is high biodiesel cost which is chiefly anxious with feedstock oil expense, because both eatable and non-eatable oils are restricted. With this, the expenditure of raw materials was accounted for in almost 70–95 percent of total cost of production. This problem can be addressed by using WASTE COOKING OIL (WCO) to reduce feedstock costs effectively to between 60 and 70% As well, catalyst costs are also affected by the overall cost of production. Several research studies were conducted in order to establish sustainable biodiesel production processes using waste material for low cost catalyst development [12].

WASTE COOKING OIL (WCO)

Waste cooking oil is the vegetable oil used in preparing food. The frequent baking of foods makes the edible vegetable oil the high Free Fatty Acid (FFA) and no longer, can be consumed [9]. Waste oil is affected by various waste issues, such as soil, water, human body and hydrophytes ecosystem disturbances [7, 9], which allow for productive and cost-effective feed for biodiesel production, rather than being disposed of and damage to the environment[7, 9, 12, 13, 17, 19]. In addition, the environmental issue is posed by high-acidity animal fats and floating fatty sludge released into the water system due to their high contamination capacity. Alternation from slaughterhouses to commercial-grade biodiesel of cheap quality lipid-rich origin is therefore an acceptable approach to reducing environmental damages while adding to the energetic challenge [18]. In addition, WCOs obtained can be used to make lubricating oil sauces and additives [7]. Several researchers have succeeded in converting used plant oil into biodiesel [2].

The vegetable oil is composed of triglycerides made from glycerol and fats esters [7] which contain saturated hydrocarbons. Used vegetable oil is a by-product of hotels, shops selling fritters, fast-food restaurants and the by-products of a working vegetable oil raffinement [10]. Some cases, street vendors used UCOs from restaurants to fry their food. The distillate developed from Palm Oil deodorization is also a good, cost-effective feedstuff [22] and can be used as second-used cooking oil by turning it into biodiesel. In addition, the need for biodiesel-produced crops and food competition is reduced by the use of wasted vegetable oil [13]. The physical and chemical characteristics of WCO vary from fresh oil, as some changes in chemical reply such as oxidations, hydrolysis, polymerisation, and the transference of material between vegetable oil and food are caused by the traditional chemical and physical features of WCOs in the frying procedure. WCOs have different properties than raw vegetable oils. [3]. The typical chemical and physical characteristics of WCO are shown in Table1

Table 1: Main properties of WCO [8]



Property	Units	Value
Density	g /cm^3	0.91-0.924
Kinematic viscosity (40^{0}C)	mm^2/s	36.4-42
Saponification value	mgKOH/g	188.2-207
Acid value	mgKOH/g	1.32-3.6
Iodine number	gI$_2$/100g	83-141.5

Rely on the frying situation, temperature and cooking time, the characteristics of WCO can change. A vegetable oil that is subjected to thermal stress such as frying will alter its original chemical and physical features completely [7]. The cooking method results in a breakdown of vegetable oil, triglycerides, diglycerides, Monoglycerides, and free fatty acids (FFAs)[13]. The amount of heat and water in the frying process enhances triglyceride hydrolysis and induces Free Fatty Acid (FFA) to expand in the WCO. [7]. However, the WCO viscosity and the saponification number increase when compared with the original oil because of the oxidation and polymerisation reactions. In addition, material and heat is transferred between the frying food and vegetable oil, resulting in a higher water content of the WCO.

In a study containing acids such as Myristic (Tetradecanoic), Palmitic (Hexadecanoic), Stearic(n-octadecanoic), Oleic, Linolenic, Arachidic and other special fats it has been concluded [2] that vegetable oleic contain acids such as myristics. Oleic and linolenic oils have been found in significant amounts, with olive, sunflower and peanut being the most commonly used vegetable oils. Moreover smaller amounts of stearic and palmitic acids, these fatty acid compounds are dominated by oleic and linoleic fatty acids [2, 7].

Other research [8] found that the results for a good product output (over 90%) would be around 37, 50 and 12% v.v.v. In triglyceride, diglycerine and monoglyceride gathering an analysis revealed that triglyceride was used with FFA (wt / wt%), 8.42 and Acid (mg KHG −1) 16.6. triglyceride was a drug that was better (above 90%). triglyceride was a source with the same concentration.

WASTE COOKING OIL TRANSESTERIFICATION

In trans-esterifcation reaction, the triglyceride component of oil reacts with the alcohol in the presence of NaOH or any other catalyst to give ester and glycerol as shown in the figure1.

In general, three systems of transesterification are available as a starting material with vegetable oil or a fat of animals and are standardized, heterogeneous and catalytic-based systems. In most cases methanol is used for better efficiency due to the reaction of UVO to alcohol[1-17, 20-23]. Ethanol may also, however, be used for animal fats[18].Transessing processes depends on the parameters of the reaction temperature and pressure, the reaction time, the agitation rate, the alcohol type used and the molecule ratio of alcohol to oil, the form and amount of catalyst employed, the moisture concentration and FFA in th. The optimum parameter values depend to a large extent on the physical and chemical characteristics of the feedstock oil for higher conversion [3, 7].

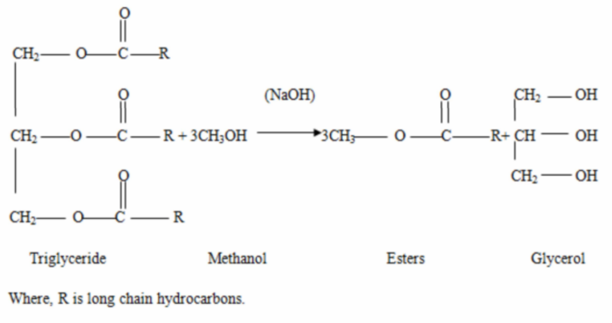


Figure1: Transesterification reaction[6]

Basically today's biodiesel is made by means of homogenous transesterification from alkaline-catalyzed vegetable oils [6, 8, 10, 11, 17, 23].Identical catalysts are solutions that can be liquid or gaseous during the reaction. The two forms are: alkaline and acidic. For the acidic catalysts of H2SO4, acidic catalysts are commonly used[6, 10] whereas transesterification catalysts such as NaOH and KOH [6, 8, 11, 17]. Home catalysts have the advantages of I catalyzing reactions with lower reaction temperature and atmospheric pressure; (ii) making high conversions possible in less time and (iii) delivering easily and [3]. The efficient use of Alkaline homogeneous catalyst is restricted to only refined vegetable oils with less than 0,5% FFA, or acid values below 1 mg KOH / g. This method allows for good product quality and comparatively less reaction time [11]. In addition, following completion of the reaction, the detachment of these catalysts involves biodieselnet washing with water, which can lead to loss of fatty acid alkyl esters, cost of energy and significant waste water generations. As catalysts are hard to restore and catalysts can cause reactor corrosion [5], the overall cost of biodiesel production increases. Triglyceride and alcohol must be anhydrusty and low fatty acid (FFA) content of raw materials will prevent soap production and low output of soap [6, 11].

One of the most promising catalysts for biodiesel development is enzymatic catalysts. They can withstand high FFA and in this reaction simultaneous esterification and transesterification occurs. Enzyme Enzyme

However, they need more catalysts, the production outcomes of which are lower than homogeneous and heterogeneous [19] are lower than the cost-effective catalysts.

WCO's ESTERIFICATION

The majority of biological diesel requirements place higher limit on the FFAs material, as FFA scanning causes damage to deposits and engines. The FFAs can be transformed to biodiesel and FFA reduction can be used as seen in figure 2. During this reaction, alcohol binds to the fatty acid ester (Biodiesel), in the presence of catalysts [13].

Figure 2: Esterification reaction [13]

The esterification phase aims to reduce WCO's acid value to a minimum. Typically, a catalytic esterification process includes the acid catalytic cycle in which acids such as sulfuric acid, hydrochloric acid, butyl-methyl imidazolium hydrogen sulfonate (BMIMHSO4) and solphonic acid are generally selected as a typical catalyst for acid[6, 10].

Oil acid value shall be determined using phenolphthalein as the measure by the titrating of the oil mix with ethanol and diethyl ether (1:1) against KOH. The acid content of the solution is determined as the value of = 56.1*CV /m, and V as the volume of KOH (mL), C as the KOH (M) AND m concentration is the weight of the oil samples as the value of (g) [8], while V is the volume of the

KOH(mL). For FFA below 1%, the feedstock can be transesterified without any pre-treatment stage with an alkali catalyst [3].

Results of a study [10] suggest that a conversion of 2 percent versus H2SO4 has been achieved. The principal inhibitor of a reversible reaction to esterification is balance. The key parameters influencing the esterification reaction are alcohol to the methanol ratio, catalyst and their usage in quantities and the reaction temperature [10, 13,17]. Water reduction by preheating in the stove will reduce FFA [10, 17].

BIODIESEL PRODUCTION

The batch and the continuous scale production of biodiesel can be achieved. Since the batch scale is straightforward, cheap and needed, less efficient workers, most industries prefer the development of batch scale. Transesterification can be done using several methods. Among them is the most common laboratory batch reactor.

Pretreatment of WCO

Preheating of oil at 500C and atm Pressure and the incidence of used oil will be used before the reaction a titration is performed to ordain how much catalyst is necessary for the reaction as well as the catalyst quantity needed to paraliszd FFAs. The oil is now passed into a cotton cloth to eliminate any bits of food particles that pass through the oil. The preheating is dependent on whether fresh or used [1] depends on the form of oil used for reaction.

Method of Lab scale Batch reactor

Such reactors typically use a 3 necks or 2 necks round bottom with a magnetic agitator and a refluence condenser. Figure3 shows the three neckled, red, ground bottle which is attached to the thermometer, condenser, and Erlenmeyer.[3] This reactor type is used in laboratories for preparing biomass diesel.

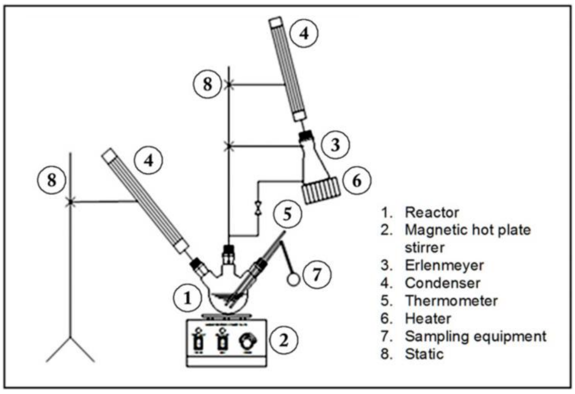


Figure 3: Transesterification batch reactor [3]

The catalyst is mixed with alcohol after the titration, which specifies the amount of catalyst required for the reaction, mixed with oil and constantly agitated in the reactor. After the reaction has been accomplished, the substance produced is divided into two layers by a funnel separated[8]. Biodiesel is the upper layer and Glycerol is the lower layer. The biological diesel formed is washed with water after this separation, so that the alcohol and catalyst are removed[1-3]. For most cases, the reaction temperature sustained by methanol as alcohol is between55 -650 celsius [8-11, 13, 18, 20, 22, 24]. Water in the liquid can be extracted by reacting using Na_2SO_4. For ethanolysis of animal fat a reaction temperature of 300C is used [18].

The study[1] showed that the 80% biodiesel yield of WCO, with a ratio of 6:1 methanol to oil, is obtainable by stirring at 300 rpm in a laboratory batch reactor at a rate of 60 ± 1 ° C for one to three hours. The NaOH is 1% wt / wt as a catalyst.

A further inquiry

More research [2] used the raw material of WFOs from friter distributors and yielded 94 per cent with a 15:1 methanol to oil ratio of NaOH at 550C for 1-1.5 hours. NaOH (0.5-1 percent wt /wt). It was also terminated that less catalyst can cause the product to be not reacted, and more catalysts can be made. The production of the final product depends very much on the free component fatty acids in the food supply.

In the research [3], 2nd cooking oils were chosen as feedstock and the maximum yield was reached by 6.18:1, KOH 1% wt / wt as a catalyst at 66.50C at a batch scale three cube-round bottoms. Within one batch scale, a maximum yield of 92.76% was achieved. The second kinetic reaction to cook oil was calculated to be k = 0.0251exp(-15.29 / RT)dm3/(mol.min).Biodiesel was derived from 877 kg / m3, Viscosity Kinematic 4.971 mm2 / s, Flash Point 180.5 0C und Pour Point 3 0C. The kinetic reaction was defined by k

Another study[5] used for the transesterification of WCO heterogeneous catalyst derived from 9000C chicken bones and developed a product yield of 89.33 percent, where 5 percent wt / wt catalyst with 15:1 methanol-oil ratio was used at 65 C for 4 hours in a 3-handle round flask. The catalyst has been found to be strong catalytic, tolerating water and high FFA for a period of 4 years.

A catalytic enriched with glycerol was used for the processing of WCO and soybean oil biodiesel [11]. It was concluded to have produced a high quality product with the use of CaO, glycerol and methanol as a solvent at 0.4 percent wt / wt with an environmental ratio of 7:1 methanol and molar oil over 2 hours at 600 C (EN 14214). The catalyst could also be reused four times. It was also reported.

In research [18] performed with a conversion of 83% to 300C with 7:1 ethanol to fat molar ratios and a 30-minute catalyst KOH as a tubular, thermostat-based glass reactor, fitted with a mechanical stirring, was carried out to biodiesel [18]. Elution through a column of silica gel in a vaccine was the biological diesel produced.

In order to achieve a conversion of 96.5-98.2 percent within 1 hour with 3 percent catalyst, methanol with the oil-mold ratio 9:1 at 650 C, an investigation [20] on alcali metals (Li, Na and K) is performed, which was assisted by ric husk silica as catalysts for the production of methyl esters.

This was also found that free fatty acid up to1.25w / w and humidity up to 1.75w / w can be provided by the catalyst. In a study [22] for the biodiesel production using a catalyst prepared from a waste material, Amazon flint kaolin, a feedstuff that is a distillate produced by deodorisation of palm oil (DDPO). A conversion of 92.8% with a methanol molar ratio of 1:60, with a strong catalyst activated with sulfuric acid, was obtained at 160 0 C for 4 hour.

Pilot Scale Reactor Method

For processing about 100 liters of biodiesel, a pilot plant is used. A study[7] used a pilot scale plant to generate bio-diesel and examined reaction temperature, alcoholic form and quantity, agitation rate, catalyst types and original oil characteristics as parameters for the reaction. An optimization process was carried out to obtain 94.3 percent biodiesel density with UVO at 3 percent FFA at 6:1 percent methanol to oil molar ratio, and 0.5 percent w/woil at NaOH.

The model and photograph of pilot plants are shown in Figure4 and Figure5. The pilot plant consists of a 100 liter R1 jacket of stainless steel. This stream is automatically filtered by WCO Filter F1 before it is loaded into the reactor. Catalyst and reagent are moved to a reactor in two tanks, D1 and D2, according to the volume and FFA percentage. The developed biodiesel is then transmitted via an ionic resin filter F2 to remove waste from the bottom of the reactor and waste resulting from the reaction. A computerized device with a touchscreen display controls all parameters.

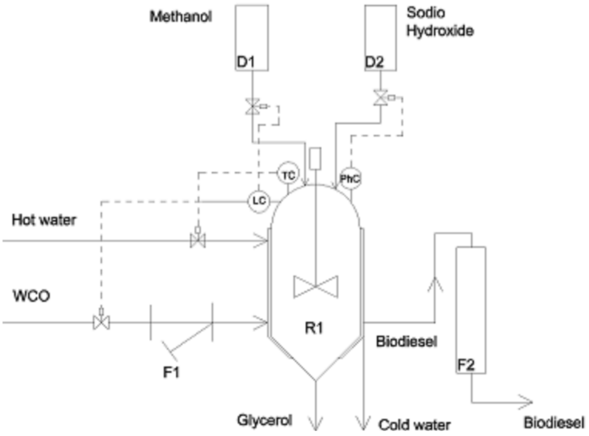


Figure 4: Pilot Plant layout [7]

Bubble column reactor method

This reactor kind is very useful in processing alcohol and lipids into biodiesel, which are poor in content. The feedstock cost and production costs will thus be reduced.

A bubbles column reactor was used in a study [7] and 95 percent was converted into an oil-molar ratio of beless of 3:1 at 120 ° C temperature at the same time, with a lower quality of vegetable oil containing a higher content of water, FFA and Methanol. At a flow rate of 0.034 moles per mole of FFA in the oil present per minute in air, the bubbling alcohol vapor was via a reactor.

Figure 5: Pilot plant for biodiesel production [7]

The schedule of a bubble spine reactor displaying bubbling reactor and the transfer of water and methanol among the fluid and vapor process is shown in Figure 6. The reactor bubble layer is jacketted by a sheet of glass. Typical reactor operation takes place at 120 ° C and 180 ml of lipid feedstock. The column top is exposed to the atmosphere so that alcohol and water will leak into a smoke cap through the reactor, in which tests are carried out. To make a catalytic solution, sulfuric acid was combined with small quantities of alcohol. Within the first 5 minutes of the reaction, a peristaltic pump is connected to the reactor at the top. The heat switches are used for methanol vaporization. The syringe pumps are for alcohol pumping.

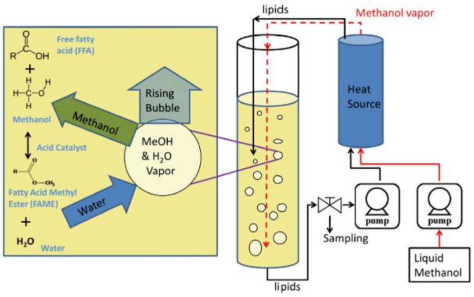


Figure 6: Schematic of reactor showing bubbling action of reactor and water and methanol transfer between liquid and vapor phase

Microwave Technique

The heat needed for the reaction is needed by a microwave oven with this process. The Micro Wave Reactor is shown in Figure7.

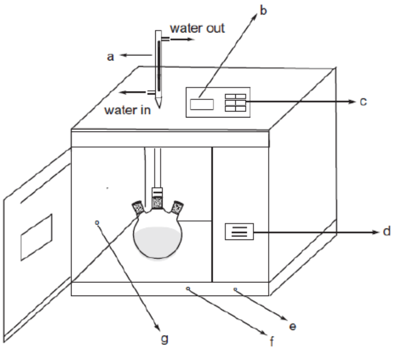


Figure 7: Accelerated reaction system schematic diagram (a) Condenser pipe; (b) panel display; (c) control panel; (d) switch chamber reaction; (e) principal switch; (f) magnetic stirring nozzle [12]

Method of Electrolysis

High-water feedstocks can directly be used in this process where anodine and cathode water hydrolysis is carried out. Figure 8 shows photos of the electrolytic cell and the equipment used in the processing of biodiesel. The picture reveals that electrodes with a distance of 15 mm are divided into graphite. The reactants are filled into an electrolytic supported container.

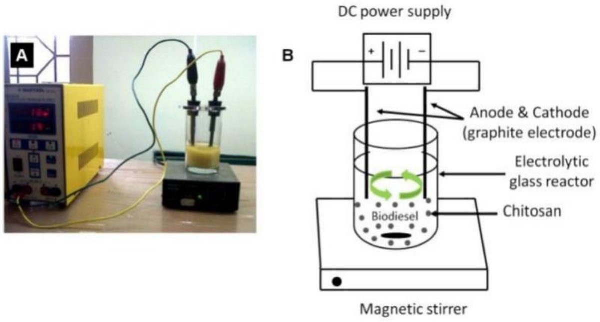


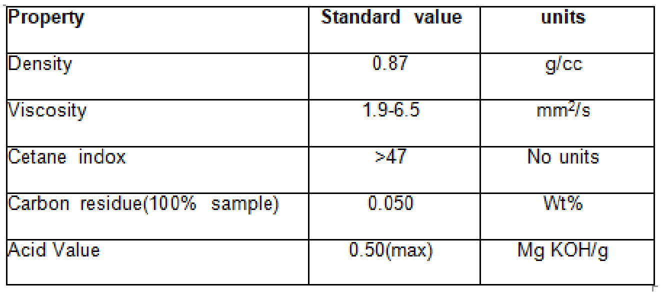
Figure 8: Photograph images of electrolytic cell (A) and designed apparatus for biodiesel production (B) [12]

A [12] research was carried out using the Electrolysis method to analyze the use of Chitosan (organo metallic catalyst) for organodiesel. The combined electrolysis cycle resulted in a conversion of 59.1 per cent, and 10 per cent chitosan was added in 4 hours. An electro-assisted cell was completed as a supporting electrolyte with the reaction mixture comprising used cooking oil and methanol, Tween 80, chitosan, deionized water and nacl. In 24:1 and methanol co-solvent to 100:1 was modified the molar ratio of methanol to crude. The degree of NaCl was 0.56%Wt / wt. Electrolysis was performed with a continuous voltage of 18 V (DC) at room temperature. Using a magnetic stirrer, the reaction mixture was agitated.

BIODIESEL PURIFICATION

The chemical compound is moved to a separating funnel after the reaction is complete where it can be settled at room temperature [1-8, 11, 15, 18] or centrifugation [5, 17]. For most cases, the blend is divided into 2 layers [1, 2]. In catalytic usage, the product developed was based on the catalyst in 3 layers [17]. Biodiesel is often the higher layer and glycerol is the lower layer. This is based on the difference in density. For elimination of minor impurities, biological diesel is isolated and washed with purified water or ethyl acetate [1, 2, 8, 13]. Washed biodiesel has been fervent to eliminate any residual moisture [2]. It also deals with Na2SO4 for water removal to produce the yellow biodiesel [8]. The study [23] indicates that the separation of glycerol from biodiesel contributes to higher yield of the drug and better fuel properties comparison to traditional water washing and silica gel usage by the distillation of unrefined biodiesel (metic esters) using activated carbon from expended tea waste. In fact, this can be regenerated and reused using the activated carbon.

Table 2: ASTM STANDARDS [1]



Property	Standard value	units
Density	0.87	g/cc
Viscosity	1.9-6.5	mm^2/s
Cetane indox	>47	No units
Carbon residue(100% sample)	0.050	Wt%
Acid Value	0.50(max)	Mg KOH/g

Table2[1] demonstrates ASTM requirements for the manufactured biodiesel. Biodiesel made by various process should be within their limits.

ENGINE DISCHARGES FUELLED WITH BIODIESEL FROM WASTE COOKING OIL

Biodiesel has, under the present scenario, been described as a possible replacement for the CI Diesel engine because both its use will reduce the consumption of fossil fuel and the emissions of engines. A group of explorer have researches the emissions attribute of biodiesel and finished that biodiesel is beneficial [9, 16, 24].Greater fluidity within the engine temperature range, pollution-free and wax free, fast inflammation, safe , and effectual burning [16] all include ideal diesel fuel characteristics.

The study [4] of the combustion characteristics of the biodiesel-fuelled engine has shown that biodiesel has decreased CO considerably whereas unburnt HC has increased NOx emissions. As a result of its lower heating benefit, biodiesel has a 5.95% rise in brake-related fuel exhaustion.

Biodiesel has been reported to be similar in nature to diesel [9]. In the case of WCO biodiesel fusion it is observed that the brake thermal productivity, CO, non-burnt hydrocarbon and flume blur were lower than diesel. Nonetheless, WCO biodiesel blends have shown their basic energy decrement and NOx to be higher than gasoline.

A different research [16] suggested that fuel mixed of up to 20% biodiesel-based waste cooking oil or 35% biodiesels in diesel fuel would satisfy existing biodiesel density and cinematic viscosity requirements. With the increased concentration of biodiesel in the diesel-biodiesel mixture, fuel thickness and density have better while the quality of the fuel was declined.

Further study [24] examined diesel engine efficiency and emission properties from different mixed fuels, e.g. DF (100% diesel), JB5 (5% jatropha biodiesel and 95% DF),

JB10 (90% DF and10% JB) and J5W5 (5% waste, 5% JB, and 90% DF). JB10 (6% DF). The emissions from JB5, JB10, and J5W5 were stated to have reduced compared to the emissions from DF by HC, CO, and CO2 emissions. In contrast to DF, NOx emissions were increased for all fuel mixtures. Therefore, parallel to diesel fuel, blending fuels completed lower noise levels because of several factors such as increased O_2 content, decreased ignition delays, increased viscosity, smoothness, etc.

CONCLUSION

Biodiesel is definitely significant substitute diesel fuel which can be consumed straightly in diesel engines without any motor modification. This has many positive attributes such as high biodegradation, reduced greenhouse gas emissions, low toxicity, non-sulfur emissions, lubricity and comes from sustainable origins like vegetable oils and animal fat etc. It is also good enough for the atmosphere and for the economy. The most popular method of biodiesel production is transesterification. Waste cooked oil is a good and cost-effective foodstuff. WCO is a decline in the total production with higher FFA material performance. Esterification should be done in this case before Transesterification.

Analogous catalysts like KOH and NaOH are recognized to have low reaction time and mild reaction, but soap formation can occur on oil with high FFA, which decreases overall production and recovery if catalysts are difficult. There is a greater separation of heterogeneous catalysts and improved product consistency but intense reaction conditions remain. Batch reactors are favored for carrying transesterification because of their quick deployment, maintenance, low cost and simple to design. The quality of the oil used depends on the higher yield of the crop. Methanol to the oil molar ratio, the catalyst used and the reaction temperature were defined for the parameters influencing the reaction. The biodiesel generated mixed with petroleum diesel proportions (80% petroleum diesel and B20: 20% biodiesel) have shown substantial reductions in emissions of CO, smoke and HC

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