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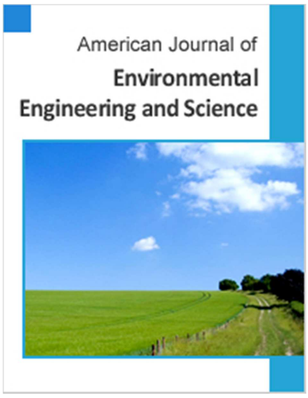

Manufacture of Biodiesel from Used Vegetable Oil as Renewable Energy and Environmental Recycled Process

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Abstract

The increasing awareness of the depletion of fossil fuel resources and the environmental benefits of biodiesel fuel has made it more attractive in recent times. Its primary advantages deal with it being one of the most renewable fuels currently available and it is also non-toxic and biodegradable. It can also be used directly in most diesel engines without requiring extensive engine modifications. However, the cost of biodiesel is the major hurdle to its commercialization in comparison to petroleum-based diesel fuel. The high cost is primarily due to the raw material, mostly neat vegetable oil. Used cooking oil is one of the economical sources for biodiesel production. However, the products formed during frying, can affect the transesterification reaction and the biodiesel properties. The production of biodiesel from vegetable oil offers a triple-facet solution: economic, environmental and waste management. Thus, biodiesel produced from recycled frying oils has the same possibilities to be utilized. From an economic point of view; the production of biodiesel is very feedstock sensitive. From a waste management standpoint, producing biodiesel from used frying oil is environmentally beneficial, since it provides a cleaner way for disposing these products; meanwhile, it can yield valuable cuts in CO_2 as well as significant tail-pipe pollution gains. This study aims to define the requirements for biodiesel production by the esterification process, testing its quality by determining some parameters such as density, kinematics viscosity, high heating value, and comparing it to Diesel fuel. Therefore, it will be extremely helpful for taking rational decisions about the development of a biodiesel production plant.

1. Introduction

Worldwide, people are increasingly interested in environmental issues and preservation of non-renewable natural resources [1]. Since many years, people are turning to products that are not polluting the environment and to those that are somehow protecting the environment [2]; [3]. Undoubtedly, biofuels have won people's interest due to their advantages against fossil fuels. This fact is constantly verified by investing huge amounts in research and development at the sector of biofuels [4]. However, it is of vital importance the biodiesel production to be in a viable basis based on the protection of the environment, natural resources and economy [5]. Towards this direction the present work aims to investigate the feasibility of a typical biodiesel production unit fed by recycled waste edible oils [6]. The research for alternative sources of energy has already begun, proving the necessity of a sustainable future [7].

Vegetable oils and their derivatives (such as methyl esters), commonly referred to as biodiesel, are prominent candidates as alternative diesel fuels [8]. They have advanced from being purely experimental fuels to initial stages of commercialization in a number of countries. The use of vegetable oil in diesel engines is not a new concept; Rudolf Diesel, reportedly used groundnut (peanut) oil as a fuel for demonstration purposes in 1900 [9]. There are however, a number of problems associated with using straight vegetable oil as a fuel for diesel engines such as high viscosity, injector coking and engine deposits [10]. These problems can be solved to a certain degree by converting the vegetable oils into their methyl esters. This is done by means of the transesterfication reaction and the resulting product, fatty acid methyl ester (FAME), is also commonly known as biodiesel [11].

Waste vegetable oil has been found to reduce the amount of particulate matter, hydrocarbons, and carbon monoxide in exhaust without any significant increase in the amount of nitrogen oxide produced [12].

Biodiesel is technically competitive to conventional fossil diesel but relatively cheap fossil diesel prices have made the technology economically unfeasible for almost a century. However, recent high and rising world crude oil prices and claims that the world oil reserves are diminishing and environmental and political pressure have caused an urge in the development of the technology of biodiesel production [13].

Though biodiesel has advantages in terms of its flexibility and applicability, the process to create it is more complicated than Waste Vegetable Oil (WVO). Biodiesel is created from animal or vegetable oil that is modified through a process called transesterification, during which triglycerides in the oil are converted to methyl and ethyl esters and glycerine [11]. First, the used vegetable oil must be filtered for food scraps and solid waste particles. The oil is then heated to remove water and titration must be performed to determine how much sodium hydroxide (NaOH) and methanol catalyst is needed. A mixture of NaOH and methanol is then mixed in to the waste oil. The NaOH can be procured in the form of lye drain cleaner while methanol is commonly found as gas tank antifreeze. The glycerin that is produced must be removed through a process of washing and drying before the biodiesel can be used as a fuel.

Waste vegetable oil has been found to reduce the amount of particulate matter, hydrocarbons, and carbon monoxide in exhaust without any significant increase in the amount of nitrogen oxide produced [12]. Performance and fuel economy for both biodiesel and WVO is roughly equivalent to petroleum diesel, though the use of high percentage biodiesel blends can impact fuel system components in older vehicles, primarily fuel hoses and fuel pump seals that contain elastomeric compounds that are incompatible with biodiesel [14]. Despite this concern over degradation of parts, the Magnuson-Moss Warranty Act, passed by Congress in 1975, prohibits auto manufacturers from refusing to honour a warranty if their product has a problem not directly caused by burning biodiesel [15]. In general, most companies will explicitly warranty blends of biodiesel ranging from five to twenty percent. The use of WVO, on the other hand, voids the majority of warranties because it involves the actual conversion of the fuel system [16]. The consideration of manufacturers recognizing warranties is more of a concern with the WVO-fuelled vehicles since they are a more recent and experimental phenomenon at this stage. The objective of this research is the Manufacture of Biodiesel from Used Vegetable Oil as Renewable Energy and Environmental Recycled Process.

The rationale of this research is to identify the important variables in the manufacture of Biodiesel from waste vegetable oil as renewable energy. The high energy demand in the industrialized world as well as in the domestic sector, had caused pollution problems due to the widespread use of fossil fuels make it increasingly necessary to develop the renewable energy sources of smaller environmental impact than the fossil fuels such diesel fuels. The alternative fuel must be technically feasible, economically competitive, environmentally acceptable and readily available that is familiar to biodiesel properties. Biodiesel also biodegradable, non-toxic and has low emission profiles as compare to diesel fuel.

2. Materials and Methods

2.1. Pressing of Rapeseed Oil

2.5 Kg of, seven- year- old rapeseed, were pressed which gave 500 ml of rapeseed oil and the pressed oil was filtered using filter paper for 24 hours. 50 ml of the filtered oil was used for the determination of the free fatty acid percentage.

2.1.1. The Determination of Free Fatty Acid

15 grams of the filtered rapeseed oil was put in 250 ml Erlenmeyer flask, and then 50 ml of diethyl ether and ethanol were added. Stirring was done until the oil was completely dissolved in the solvent mixture. A burette was filled with about 10-15 ml of ethanolic KOH solution, 3-4 drops of phenolphthalein (1% in ethanol) and a magnetic stir bar were given to the solution in the Erlenmeyer flask, and then the KOH solution was added to the mixture (mixture titration). When the colour of the mixture changed, the mixture was left another 30 second to be sure of the new colour. Formula used to determine the concentration of free fatty acid in Rapeseed oil:

$$\text{Percentage (\%) free fatty acid} = \frac{a \times avg.mol.weight}{10 \times E} \quad (1)$$

Where:
a = volume (ml) of KOH × 0.1 (mol/ml)
avg.mol.weight = 314 g/mol
E = initial weight in grams

2.1.2. Transestrification

The rapeseed oil was heated up to 30°C, and was put on a stir, the KOH was dissolved in the Methanol and slowly the methanol-KOH was allowed into the oil in drops and the oil was left to the next day.

2.2. Thin Layer Chromatography (TLC)

A good way to check for impurities; how many different compounds are in a sample, very small quantities of the samples are placed on the special TLC plates. The plate is put in a container with a solvent or solvent mixture, the solvent runs up the plate and will separate the different kinds of molecules based on polarity differences and size differences.

2.3. Technical Details and Standards of Diesel and Biodiesel

There are three existing specification standards for diesel and Biodiesel fuels (EN590, DIN 51606 and EN14214).

EN590 describes the physical properties that all diesel fuel must meet if it is to be sold anywhere in the country. It allows the blending of up to 5% Biodiesel.

DIN 51606 is a standard for Biodiesel, is considered to be the highest standard currently existing, and is regarded by almost all vehicle manufacturers as evidence of compliance with the strictest standards for diesel fuels. The vast majority of Biodiesel produced commercially meets or exceeds this standard.

EN14214 is the standard for biodiesel now having recently been finalized by the European Standards organisation which is broadly based on DIN 51606.

Table 1. *Some Properties of Diesel and Biodiesel Standards.*

Properties	Unit	Derv. (EN590)	Biodiesel DIN51606	Biodiesel EN14204
Density at 15°C	g/cm^3	0.82-0.86	0.875-0.9	0.86-0.9
Viscosity at 40°C	mm^2/s	2.0-4.5	3.5-5.0	3.5-5.0
Flashpoint	°C	>55	>110	>101
Sulphur	%mass	0.20	<0.01	<0.01
Carbon Residue	(% weight)	0.30	<0.03	<0.03
Total Contamination	mg/kg	Unknown	<20	<24
Cetane Number	-	>45	>49	>51

Derv. diesel oil used in cars and lorries with diesel engine from d(iesel), e(ngine), r(oad), V(ehicle)

2.4. Kinematic Viscosity Measurement: The Ubbelohde Viscometer

Viscosity refers to a fluid's resistance to flow at a given temperature. A fuel that is too viscous can hinder the operation of an engine. Kinematic viscosity measures the ease with which a fluid will flow under force. It is different from absolute viscosity, also called dynamic viscosity.

Kinematic viscosity is obtained by dividing the dynamic viscosity by the density of the fluid. If two fluids with the same absolute viscosity are allowed to flow freely on a slope, the fluid with higher density will flow faster because it is heavier. The density of biodiesel varies depending on its feedstock. Longer and straighter chains (saturated fats) tend to have higher density than shorter and unsaturated molecules. Kinematic viscosity allows comparison between the engine performances of different fuels, independent of the density of the fuels. Two fuels with the same kinematic viscosity should have the same hydraulic fuel properties, even though one fuel may be denser than the other. The highest acceptable kinematic viscosity for biodiesel as specified in D6751 is 6.0. EN 14214, the biodiesel standard, specifies a viscosity limit for biodiesel of 3.5–5.0 mm^2/s. If a batch of biodiesel does not meet this specification, the viscosity can be corrected by blending it with a fuel that has a lower or higher viscosity.

The Ubbelohde type viscometer is a measuring instrument which uses a capillary based method of measuring viscosity. The device was invented by the German chemist Leo Ubbelohde (1877-1964). The Ubbelohde viscometer is a u-shaped piece of glassware with a reservoir on one side and a measuring bulb with a capillary on the other. A liquid is introduced into the reservoir then sucked through the capillary and measuring bulb. The liquid is allowed to travel back through the measuring bulb and the time it takes for the liquid to pass through two calibrated marks is a measure for viscosity. The Ubbelohde device has a third arm extending from the end of the capillary and open to the atmosphere. In this way the pressure head only depends on a fixed height and no longer on the total volume of liquid. The advantage of this instrument is that the values obtained are independent of the concentration.

3. Results

Table 2. *Experimental Results of Kinematic Viscosity for rapeseed oil, two types of biodiesels and diesel fuel.*

Fuel Type	Kinematic Viscosity (mm^2/s)
Rapeseed Oil	36.22
Biodiesel (lab)	5.706
Biodiesel (Gas Station)	4.454
Diesel	3.095

Table 2 shows the experimental results of kinematic viscosity for rapeseed oil, two types of biodiesel and diesel fuel. It could be noticed from the table that the rapeseed oil has the highest viscosity among the other fuels because vegetable based oils tend to be fairly viscous and don't flow too easily. Also, it could be noticed that diesel has lowest viscosity. Biodiesel of the two types has higher viscosity than diesel specially the one produced in the laboratory because not all of rapeseed oil was converted completely to biodiesel, it had a little amount of rapeseed oil and it's known that rapeseed oil has high viscosity.

3.1. Density Measurement: Hydrometer and Pycnometer

Density is the weight per unit volume. Diesel fuels have higher densities and therefore it gives more energy than that of the petrol. The densities of the vegetable oils are higher, but during the transesterification process the density is decreased, however they are denser than the diesel fuels and thereby they are an efficient alternative.

3.1.1. Hydrometer

A hydrometer is an instrument used to measure the specific gravity (or relative density) of liquids; that is, the ratio of the density of the liquid to the density of water. A hydrometer is usually made of glass and consists of a cylindrical stem and a bulb weighted with mercury or lead shot to make it float upright. The liquid to be tested is poured into a tall container, often a graduated cylinder, and the hydrometer is gently lowered into the liquid until it floats freely. The point at which the surface of the liquid touches the stem of the hydrometer is noted. Hydrometers usually contain a scale inside the stem, so that the specific gravity can be read directly. Varieties of scales exist, and are used depending on the context.

3.1.2. Pycnometer

A pycnometer is a small flask with a glass stopper. A capillary opening which runs along the length of the stopper makes it possible to fill the pycnometer completely- that is, without leaving a bubble of air in the flask.

Table 3. *Experimental Results of Densities for rapeseed oil, two types of biodiesels and diesel fuel.*

Fuel Type	Density (g/cm^3)	
	Hydrometer	Pycnometer
Rapeseed Oil	0.921	0.922
Biodiesel (lab)	0.880	0.879
Biodiesel (Gas Station)	-	0.885
Diesel	-	0.825

Table 3 shows the experimental results of Density for rapeseed oil, two types of biodiesel and diesel fuel. It could be noticed for rapeseed oil and biodiesel produced in the laboratory, density was measured by hydrometer and pycnometer, it can be noticed that rapeseed oil has the highest density because vegetable oils are denser in their chemical structure. Also, it could be noticed that diesel and biodiesel have close densities, with higher density for biodiesel due to the fact that biodiesel is made out of vegetable oil and that it is not converted to 100% biodiesel.

3.2. Heating Value Measurement: The Bomb Calorimeter

Heating value or Heat of combustion is the amount of heating energy released by the combustion of a unit value of fuels. The most important determinants of the heating value are the moisture content. It is because of this, that the purified Biodiesel is dried. The moisture content of the Biodiesel is low and this increases the heating value of the fuel.

A bomb calorimeter is a type of constant-volume calorimeter used in measuring the heat of combustion of a particular reaction. Bomb calorimeters have to withstand the large pressure within the calorimeter as the reaction is being measured. Electrical energy is used to ignite the fuel; as the fuel is burning, it will heat up the surrounding air, which expands and escapes through a tube that leads the air out of the calorimeter. When the air is escaping through the copper tube it will also heat up the water outside the tube. The temperature of the water allows for calculating calorie content of the fuel.

The calorimeter gives the value of the high heating value or the GROSS (or higher) calorific value for a fuel. The net calorific value is then obtained by subtracting the latent heat of the water present from the gross calorific value. The latent heat of vaporization of water is 2.5MJ/kg.

Table 4. *Experimental Results of Lower Heating Value for Rapeseed Oil, Two Types of Biodiesel and Diesel Fuel.*

Fuel Type	Lower Heating Value (KJ/Kg)
Rapeseed Oil	36922
Biodiesel (lab)	37510
Biodiesel (Gas Station)	38105
Diesel	46221

Table 4 shows the experimental results of Lower heating value for rapeseed oil, two types of biodiesel and diesel fuel. It could be noticed that diesel has the highest heating value, which means that the energy released of diesel combustion is the highest, while biodiesel comes in the second place of amount of energy released and the last one is the rapeseed oil.

3.3. Measuring the Oxidation Stability

Because of the chemical structure of fatty acid methyl esters (FAME), they age more quickly than fossil diesel fuels. Therefore it was considered to include a limit for oxidation stability in the existing quality standard for biodiesel. Oxidative stability is an important parameter in the characterization of fats and oils.

Transestrification of vegetable oils with methanol produces the methyl esters of the fatty acids (together with glycerol as a by-product). These have only a limited shelf-life as they are slowly oxidized by atmospheric oxygen. The resulting oxidation products can cause damage to combustion engines. This is why oxidation stability is an important quality criterion for biodiesel, which needs to be regularly determined during production. With the Rancimat this determination can be carried out quickly and simply, and the value is given in hours.

The fuel sample is heated up to 110^0 C, compressed air is supplied through the fuel into a flask with distilled water.

Conductivity of the distilled water is measured; when it raises the fuel begins to deteriorate. The oxidation stability of diesel is measured differently from rapeseed oil and biodiesel. Diesel is heated up to 95°C for 16 hours and exposed to 3 liter per hour of pure oxygen (accelerated aging), because of the aging resin will be formed in the diesel (deterioration of diesel), the concentration of resin in the diesel is measured and the value is given in gram per cubic meter.

Table 5. *Experimental results of Oxidation stability for rapeseed oil, two types of biodiesel and diesel fuel.*

Fuel Type	Oxidation Stability (hours)
Rapeseed Oil	3.03
Biodiesel (lab)	18.78
Biodiesel (Gas Station)	7.640
Diesel	16.38

Table 5 shows the experimental results of Oxidation stability for rapeseed oil, two types of biodiesel and diesel fuel. It could be noticed from table 5 that the oxidation stability for rapeseed oil is 3.03 hours, and in the standard results for rapeseed oil, shown in table 6, the minimum is 5 hours, this due to that the rapeseed oil which was used in the laboratory was not a fresh one, it was one year old oil.

Table 6. *Characteristic Properties for Rapeseed oil according to DIN 51605.*

Properties	Unit	Limiting Value	
		Min.	Max.
Density at 15°C	Kg/m^3	900	930
Kinematic Viscosity at 40°C	mm^2/s	-	38
Calorific Value	KJ/kg	3500	-
Oxidation Stability at 110°C	h	5.0	-

Table 7. *Characteristic Properties for Rapeseed oil according to experiments done in the Laboratory.*

Properties	Unit	Value
Density at 15°C		
Hydrometer	Kg/m^3	921
Pycnometer		922
Kinematic Viscosity at 40°C	mm^2/s	36.22
Lower heating value	KJ/kg	36922
Oxidation Stability at 110°C	h	3.03

For the oxidation stability of biodiesel which was produced in the laboratory, the value isn't reasonable (18.78) as shown in table 5. There's a very big difference between the standard value (6 h) shown in table 8 (6 hours), this could be due to a fault in the experiment e.g. compressed air which was supplied to the biodiesel could have failed for some hours during the night.

Table 8. *Characteristic Properties for Biodiesel according to Standard EN14214.*

Properties	Unit	Standard EN14214
Density at 15°C	g/cm^3	0.86 – 0.90
Kinematic Viscosity at 40°C		
Min.	mm^2/s	3.5
Max.		5.0
Lower Heating Value	KJ/kg	3600
Oxidation Stability at 110°C	h	6.0

Table 9. *Characteristic Properties for Rapeseed oil according to experiments done in the Laboratory.*

Properties	Unit	Value	
		Biodiesel (Lab)	Biodiesel (gas station)
Density at 15°C			
Hydrometer	g/cm^3	0.880	-
Pycnometer		0.879	0.885
Kinematic Viscosity at 40°C			
Min.	mm^2/s	5.706	4.454
Max.		-	-
Lower heating value	KJ/kg	37510	38105
Oxidation Stability at 110°C	h	18.78	7.640

For biodiesel, from gas station, it could be noticed that the oxidation stability result shown in table 5 (7.640 hours), is close to the European Standard EN 14214 of biodiesel shown in table 8 (6 hours) this is because it's commercial biodiesel which is sold in gas stations, where it should meet the standards of biodiesel.

Table 10. *Characteristic Properties for Diesel according to the DIN EN 590 Standards.*

Properties	Unit	Value	
		Min.	Max.
Density at 15°C	Kg/m^3	820	845
Viscosity at 40°C			
Min.	mm^2/s	2.00	4.50
Max.			
Lower heating value	KJ/kg	42500	
Oxidation Stability at 110°C	g/ml	25	

Table 11. *Characteristic Properties for Rapeseed oil according to experiments done in the Laboratory.*

Properties	Unit	Value
Density (Pycnometer) at 15°C	g/cm^3	0.825
Viscosity at 40°C	mm^2/s	3.095
Lower heating value	KJ/kg	46221
Oxidation Stability at 110°C	h	16.38

For diesel fuel the oxidation stability is measured in a different way than that for rapeseed oil and biodiesel, here the result of oxidation stability for diesel which was got from the laboratory, was done by the rancimant method as for rapeseed oil and biodiesel but it's not accurate for diesel. The oxidation stability for diesel according to the standard method couldn't not be performed in the lab because the experiment needs pure oxygen, which gives a very flammable mixture together with diesel and the laboratory is not equipped for that.

4. Discussion of Results

Comparing between experimental and standard of the fuel analytics results of rapeseed oil, diesel and biodiesel. For the biodiesel which was produced from rapeseed oil in the laboratory, it could be noticed that it's not of high quality. That could be noticed from the colour of the biodiesel compared to the commercial biodiesel (from the gas station). Also, the oxidation stability experiment (18.78 h) could show the low quality of biodiesel produced in the laboratory because comparing it to commercial biodiesel (7.64 h) both in table 9. That is due to the fact that commercial biodiesel undergoes additional steps once the transestrification is completed, such as the removal of the excess alcohol in glycerin and biodiesel phases is removed with a flash evaporation process or by distillation and Methyl Ester Wash. Also, the biodiesel is sometimes purified by washing gently with warm water to remove residual catalyst or soaps, dried, and sent to storage, resulting in a clear amber-yellow liquid with a viscosity similar to petro-diesel, which is the colour of the commercial biodiesel.

For the results of the properties that were determined for rapeseed oil, diesel and two types of biodiesel (produced in laboratory and from gas station), which were the density, the kinematic viscosity, the lower calorific value and the oxidation stability. These results were compared to the standard values. For rapeseed oil, it could be noticed that most of the experimental results of the density, the kinematic viscosity, and the lower calorific value shown in table 7, are very close to the Rapeseed Oil Fuel Standard DIN 51605 shown in table 6. For the experimental result of the oxidation stability, it can be noticed that in the standard results, the min. is 5 hours (table 6) and the result that was got in the laboratory was 3.03 hours (table 7) and this due to that the rapeseed oil which was used in the laboratory was not a fresh one, it was one year old oil.

For biodiesel, from gas station, it could be noticed that most of the experimental results of the density, the kinematic viscosity, the lower calorific value and the oxidation stability shown in table 9, are very close to the Standard EN 14214 of biodiesel shown in table 8. This is because it's commercial biodiesel which is sold in gas stations, where it should meet the standards of biodiesel.

For biodiesel, produced in the laboratory and as was mentioned before, it's not of high quality as commercial biodiesel. It could be noticed from the experimental results shown in table 9, of the density, and the lower heating value that they are close to the European Standard EN 14214 of biodiesel. But for the kinematic viscosity, it could be noticed that the experimental result (5.706 mm^2/s) is a little bit higher than the max. of the standard value (5 mm^2/s) and this because the biodiesel produced in the laboratory was not converted completely to biodiesel, it had a little amount of rapeseed oil and it's known that rapeseed oil has high viscosity, so that's why the biodiesel had higher viscosity. For the oxidation stability, there's a very big difference between the standard value (6 h) table 8 and the experimental one (18.78 h) table 5. This value is too high to be reasonable, this could be due to a fault in the experiment e.g. compressed air which was supplied to the biodiesel could have failed for some hours during the night.

For diesel fuel, it could be noticed that most of the experimental results of the density, the kinematic viscosity, and the lower calorific value shown in table 11, are very close to the EN 590 standards of diesel shown in table 10. This is because it's commercial diesel which is sold in gas stations, where it should meet the standards of diesel fuel. But for the oxidation stability, in the standard results, it's measured in grams per cubic meters and not in hours as in the standard results for rapeseed oil and biodiesel, this is because the oxidation stability for diesel is measured in a different way than that for rapeseed oil and biodiesel. Here the result of oxidation stability for diesel which was got from the laboratory, was done by the rancimant method as for rapeseed oil and biodiesel but it's not accurate. Unfortunately, the oxidation stability for diesel according to the standard method couldn't not be performed in the lab because the experiment needs pure oxygen, which gives a very flammable mixture together with diesel and the lab is not equipped for that.

5. Conclusion

In a world where every action must be weighed against its demerits, where everything should be balanced between power and the environment, in a world like today, where petroleum reserves are becoming limited and will eventually run out and the critical issue of oil peak and the environmental concerns, all have prompted deeper research into the area of alternatives to fossil fuels which are biofuels such as biodiesel and bioethanol. Biodiesel has become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. Biodiesel is briefly defined as the monoalkyl esters of vegetable oils or animal fats. Biodiesel is the best candidate for diesel fuels in diesel engines. It burns like petroleum diesel as it involves regulated pollutants. So it necessary to implement the use of biodiesel over the current petroleum and gasoline because of all the merit and advantages it brings forth to the table. In comparison to petroleum and gasoline, biodiesel beats its competitors in all categories of toxic substance emissions and poses close to no threat to the environment. What's more, instead of increasing the carbon dioxide levels in the atmosphere, the overall production and use of biodiesel consumes more carbon dioxide than it emits, thus making it a valuable tool in preventing global warming.

Not only does petroleum diesel harm our environment through emissions of toxic substances, but it also has negative effects on us physically. Many health problems and illnesses have been traced back to emissions from petroleum diesel. These emissions have been related to many cases of cancer, cardiovascular and respiratory disease, asthma and infections in the lungs. By using biodiesel in the place of petroleum diesel, not only will we be helping the environment with a much better alternative, but we would be significantly reducing many health risks.

The fact that most biodiesels are domestically produced means that by using more of it, the market of biodiesel would actually stimulate the economy, reducing a country's dependence on foreign oil imports. Also, the implementation of biodiesel is extremely easy and requires little or no modifications to the typical diesel engine, making it a very easy and smooth transition. When we weigh the advantages of biofuel against its disadvantages, it is clear that it brings more than it takes away because biofuels are easily available from common biomass sources, carbon dioxide cycle occurs in combustion, they are very environmentally friendly, and they are biodegradable and contribute to sustainability.

The production of biodiesel from waste vegetable oil offers a triple-facet solution: economic, environmental and waste management. The new process technologies developed during the last years made it possible to produce biodiesel from recycled frying oils comparable in quality to that of virgin vegetable oil biodiesel with an added attractive advantage of being lower in price. Thus, biodiesel produced from recycled frying oils has the same possibilities to be utilized.

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