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Application of Cocos Nucifera L and its Efficiency in Production of Biodiesel

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Abstract

Transesterification of vegetable oils, which is coconut oil, is carried out by using methanol and potassium hydroxide as catalyst. Methyl ester of vegetable oils or biodiesel have several outstanding advantages among any other renewable and clean engine furl alternatives and can be used in any diesel engine without modification. The most important variables affecting the methylester yield during the transesterification reaction are molar ratio of alcohol to vegetable oil and reaction temperature. All vegetable oils are more viscous, while the methyl esters of vegetable oils are slightly more viscous. Biodiesel has become more attractive because of its environmental benefits. The cost of biodiesel, however is the main obstacle to commercial. With cooking oil as a raw material, viability of a continuous transesterification process and recovery of high quality glycerol as a biodiesel by-product are primary options to be considered to lower the cost of biodiesel. In transesterification the reaction time is 24 hours for settling process. Viscosity of vegetable oils is 43.3 mm2/s get reduced in vegetable oil methyl esters at 4.5mm2/s and B20 is 6.3 mm2/s. A slightly decrease in density from 0.903g/ml to 0.765 g/ml for vegetable oil methyl esters decrease the viscosity from 43.3mm to 4.5mm2/s.

Keywords: Transesterification, Coconut oil, Biodiesel

1.0 Introduction

Mechanical energy cannot be achieved successfully without petroleum, natural gas, coal, hydroelectricity and nuclear energy and they became the basic natural sources for the energy. The demand of petroleum and its by-products are increasing continuously due to the increase in population and industrialization. The discriminate use of petroleum sourced fuels is now widely recognized as unsustainable because it is non-renewable resources. In the last 10 years, many studies have been conducted on biofuels for substituting fossil fuels and reduce the greenhouse gas (GHG) emission which is responsible for global warming (Bastianoni et al., 2008). Energy is one of the main human needs and currently energy resources are running low. It caused by a commonly used fuel derived from petroleum which is not renewable and difficult to obtain because over a period of thousands of years. The energy crisis that hit this time is a problem that must be addressed. Continuous exploitation of the fossil fuels which are non-renewable energy consumption for industry, transport and households resulted in dwindling presence in nature. It has been led to the level of oil consumption to an average rise of 6% per year (Suroso, 2005). With such issues like global warming, air pollution, and other environmental problems that have resulted somewhat from using fossil fuels to create energy, the future must include the use of clean burning fuels instead of fossil fuels.

1.1 Important Of Biomass

Biomass energy can be implemented on a very large scale with almost no modifications and this is a much cleaner burning fuel source comparing to fossil fuels. Investing in renewable alternative sources of energy now means that in 10 or 20 years, dependence on foreign oil and fossil fuels will no longer be a problem.

There is also wind farms that create so much energy that excess is sold to power companies and there are homes that use solar energy in combination with other traditional energy sources. Cars have been created that can run on gasoline blends that burn up to 85 percent ethanol mixed with 15 percent gasoline. Vehicles that burn this fuel blend are called flexible fuel vehicles and are very friendly to the environment and a tight budget. Surely, energy in the future will see a lot more biomass energy production, biofuels being used exclusively, and alternative energy sources becoming common and standard.

1.2 Advantages Of Biofuels

Biofuels can come from a wide variety of sources and can be roughly divided into four categories or "generations". First generation biofuels are made from sugars, starches, oil, and animal fats that are converted into fuel using already-known processes or technologies. These fuels include biodiesel, bio-alcohols, ethanol, and bio-gasses, like methane captured from landfill decomposition. Second generation biofuels are made from non-food crops or agricultural waste, especially lingo-cellulosic biomass like switch-grass, willow, or wood chips. Third generation biofuels are made from algae or other quickly growing biomass sources. Fourth generation biofuels are made from specially engineered plants or biomass that may have higher energy yields or lower barriers to cellulosic breakdown or are able to be grown on non-agricultural land or bodies of water.

This study was conducted to determine the proficiency of Coconut (Cocos Nucifera L.) in production of biodiesel. The demand of petroleum and its by-products are increasing continuously due to the increase in population and industrialization. The discriminate use of petroleum sourced fuels is now widely recognized as unsustainable because it is non-renewable resources. In the last 10 years, many studies have been conducted on biofuels for substituting fossil fuels and reduce the greenhouse gas (GHG) emission which is responsible for global warming. Energy is one of the main human needs and currently energy resources are running low. It caused by a commonly used fuel derived from petroleum which is not renewable and difficult to obtain because over a period of thousands of years. Coconut (Cocos Nucifera L.) is chosen in this study as a raw material in production of biodiesel.

1.3 Objective

The objective for this study:

1. To investigate the efficiency of using Coconut Biodiesel as an alternate fuel substitute for diesel engines.
2. To investigate the physical properties of coconut as a raw material for production of biodiesel.
3. As a direct substitute and additive for petroleum-diesel and bio-diesel.

1.4 Scope of Study

This study focused on the application of Coconut (Cocos Nucifera L.) as a raw material for production of biodiesel. This study is to see the efficiency of coconut in production biodiesel and as a alternative fuel due to the increasing of fuel prices and the lack of fossil fuels

2.0 Literature Riview

2.1 Biodiesel

Biodiesel is a clean-burning, a renewable fuel alternative to conventional diesel. Biodiesel can be in variety forms of fats and agricultural commodities which consists of oilseeds for example canola and soybean, used cooking oil and palm oil. It can also be made from biomass such as from coconut. The conversion of oils into chemicals is identified as a long chain mono alkyl ester or known as biodiesel. During the process, 100 pounds of oils or fats are reacted with 10 pounds of a short chain alcohol typically methanol in the existence of catalyst typically Potassium Hydroxide to form 100 pounds of biodiesel and 10 pounds of glycerine which is a by-product of biodiesel process (Gerhard Knothe, 2009) Producing biodiesel is a relatively simple process of bonding alcohol to fats or oils. The use of its pure form may be necessitate certain engine modifications to avoid maintenance or problems in performance. Nevertheless, it is mostly found mixed at a ratio of 20% of biodiesel and 80% of petroleum diesel (Gerhard Knothe, 2009). General parameter that is a standard for biodiesel efficiencies are density, flash points, kinematic viscosity, cetane number, sulphuric ash, and carbon residue (E., 2007) The processed of biodiesel is come from various sources by using the common reaction and separation system. There are six processes or system that are currently use at pilot and industrial scale; batch processes using transesterification, continuous processes that required high operating pressure and temperature, hydrolysis and esterification processes that produced high purity of glycerol, enzymatic processes that have low energy consumption, and hydro-pyrolysis 17 processes that required more complex equipment and implies that availability of a low-cost hydrogen course (Susilowati, 2010).

2.2 Vegetable Oils

Most vegetable oils are triglycerides (TGs; triglycerides=TG). Chemically, TGs are the triglycerides esters of various fatty acids with glycerol (Figure 2.3). Some physical properties of the most common fatty acids occurring in vegetable oils and animal fats as well as their methyl esters are listed in Table 2.2. Besides these fatty acids, numerous other fatty acids occur in vegetable oils and animals fats, but their abundance usually is considerably lower. Table 2.1 lists the fatty acid composition of some vegetable oils and animal fats that have been studied as sources of biodiesel.

CH_2OOR						CH_2OH
CHOOR	+	3 CH_3OH	→	3 CH_3OOCR	+	CHOH
CH_2OOR						CH_2OH
Triglyceride		Methanol		Methyl Ester		Glycerol

Figure 2.3: Structure of triglycerides and principle of the transesterification reaction

The most common derivatives of TGs or fatty acids for fuels are methyl esters. These are formed by transesterification of the TG with methanol in presence of usually a basic catalyst to give the methyl ester and glycerol as in Figure 2.3. Other alcohols have been used to generate esters, for example, the ethyl, propyl, and butyl esters (Gerhard Knothe, 2009)

Table 2.1: Major fatty acids (in wt. -%) of some oils and fats used or tested as alternative diesel fuels (Gerhard Knothe, 2009)

Oil or Fat	Fatty Acid Composition (Wt. - %)							
	12:0	**14:0**	**16:0**	**18:0**	**18:1**	**18:2**	**18:3**	**22:1**
Babassu	44-45	15-17	5.8-9	2.5-5.5	12-16	1.4-3	-	-
Canola	-	-	4-5	1-2	55-63	20-31	9-10	1-2
Coconut	44-51	13-18.5	7.5-10.5	1-3	5-8.2	1.0-2.6	-	-
Corn	-	-	7-13	2.5-3	30.5-43	39-52	1	-
Cottonseed	-	0.8-1.5	22-24	2.6-5	19	50-52.5	-	-
Linseed	-	-	6	3.2-4	13-37	5-23	26-60	-
Olive	-	2.3	7-18.3	1.4-3.3	55.5-84.5	4-19	-	-
Palm	-	0.6-2.4	32-46.3	4-6.3	37-53	6-12	-	-
Peanut	-	0.5	6-12.5	2.5-6	37-61	13-41	-	1
Rapeseed	-	1.5	1-4.7	1-3.5	13-38	9.5-22	1-10	40-64
Safflower	-	-	6.4-7.0	2.4-29	9.7-13.8	75.3-80.5	-	-
Safflower, high-oleic	-	-	4-8	2.3-8	73.6-79	11-19	-	-
Sesame	-	-	7.2-9.2	5.8-7.7	35-46	35-48	-	-
Soybean	-	-	2.3-11	2.4-6	22-30.8	49-53	2-10.5	-
Sunflower	-	-	3.5-6.5	1.3-5.6	14-43	44-69.7	-	-
Tallow (beef)	-	3-6	25-37	14-29	26-50	1-2.5	-	-

Table 2.2: Fuel-related properties and iodine values of various fats and oils (Gerhard Knothe, 2009)

Oil or Fat	IV	CN	HG (kJ/kg)	Viscosity (mm^2/s)	CP (°C)	PP (°C)	FP (°C)
Babassu	10-18	38	37500	27.84			
Castor	82-88		39500	297 (38°)		-31.7	260
Coconut	6-12	60	42000	43.3 (38°)			
Corn	103-140	37.6	39500	34.9(38°)	-1.1	-40.0	277
Cottonseed	90-119	41.8	39468	33.5(38°)	1.7	-15.0	234
Crambe	92	44.6	40482	53.6(38°)	10.0	-12.2	274
Linseed	168-204	34.6	39307	27.2(38°)	1.7	-15.0	241
Palm	35-61	42	41240	5.7			183
Peanut	80-106	42.8	39782	39.6(38°)	12.8	-6.7	271
Rapeseed	94-120	37.6	39709	37.0(38°)	-3.9	-31.7	246
Safflower	126-152	41.3	39519	31.3(38°)	18.3	-6.7	260
Safflower, high-oleic	90-100	49.1	39516	41.2(38°)	-12.2	-20.6	293
Sesame	104-120	40.2	39349	35.5(38°)	-3.9	-9.4	260
Soybean	117-143	37.9	39623	32.6(38°)	-3.9	-9.4	260
Sunflower	110-143	37.1	39575	37.1(38°)	7.2	-15.0	274
Tallow (beef)	35-48	-	40054	51.15(40°)	-	-	201

2.3 FUEL-RELATED PROPERTIES STANDARD

The physical and chemical properties can is investigated for the production of biodiesel for use in diesel engine. The chemical and physical properties can be investigates for instance kinematic viscosity, flash point, density and others. The standard of each property can be follow as below:

Table 2.3: **Suggested ASTM standard for pure (100%) biodiesel (Kuhn, 2009)**

Properties	ASTM Method	Limits	Units
Flash Point	93	100.0 min	°C
Water and Sediment	1796	0.050 max.	Vol. -%
Carbon Residue, 100% sample	4530	0.050 max.	Wt. -%
Sulfated Ash	874	0.020 max.	Wt. -%
Kinematic Viscosity, 40°C	445	1.9-6.0	mm^2/s
Sulphur	2622	0.05 max.	Wt. -%
Cetane Number	613	40 min.	
Cloud Point	2500	No limit	°C
Copper Strip Corrosion	130	No. 3b max	
Acid Number	664	0.80 max.	mg KOH/g
Free Glycerol	GC	0.20 max.	Wt. -%
Total Glycerol	GC	0.40 max.	Wt. -%

This specification is the process of being evaluated by ASTM. A considerable amount of experience exists in the U.S. with a 20 percent blend of biodiesel with 80 percent petroleum-based diesel. Although biodiesel can be used in the pure form, use of blends of over 20 percent biodiesel should be evaluated on a case-by-case basis until further experience is available.

2.4 FUEL FORMULATING TECHNIQUES

The alternative diesel fuels must be technically and environmentally acceptable and economically viable. In these requirements, triglycerides (vegetable oils or animal fats) and their derivatives shall be considered as viable alternatives for diesel fuels. But there are problems in substituting triglycerides for diesel fuels where mostly vegetable oils are associated with high viscosities, low volatilities and polyunsaturated character. One of the major problems of vegetable oil use in diesel engines is their higher kinematic viscosity due to heavier triglycerides, and phospholipids, in which problems will occur in pumping and atomization, ring sticking, carbon deposits on the piston, cylinder head, etc. Straight vegetable oils are less suitable as fuels for diesel engines since they have to be modified to bring their combustion related properties especially viscosity get closer to mineral diesel. Heating or pyrolysis, dilution or blending, micro emulsification and transesterification are some well-known techniques available to overcome higher viscosity related issues associated with the use of vegetable oil in diesel engines and to make them compatible to the hydrocarbon based diesel fuels.

2.4.1 Heating or Pyrolysis

Heating or pyrolysis is the process by which high molecular weight compound breaks into smaller compounds by means of heat or without catalyst. The liquid fractions of the thermally decomposed vegetable oils are likely to get converted into liquid oils. Many investigators have studied the pyrolysis of triglycerides to obtain products suitable for diesel engines (Jani Lehto, 2013). The pyrolyzate oils have almost same viscosity, flash point, and pour point that of diesel fuel. The cetane number of the pyrolyzate oil has been found to be lower. The pyrolyzate oils from vegetable oils contain acceptable sulphur content, water and sediment and give acceptable copper corrosion valued but unacceptable ash and carbon residues. Mechanisms for the thermal decomposition of triglycerides are likely to be complex because of many structures and multiplicity of possible reactions of mixed triglycerides (Jani Lehto, 2013).

2.4.2 Dilution or blending

High viscosity fuels like vegetable oils can be mixed with low viscosity fuel like petroleum diesel to overcome overall viscosity. These blends then can be used as diesel engine fuels. The dilution can be accomplished with a solvent, methanol or ethanol. Vegetable oils can be directly mixed with diesel and may be used to run diesel engines. Blending of vegetable oils with diesel has been tried successfully by a number of researches. They concluded that the blend could not be recommended for a long term use in the direct injection diesel engines. Aaron Williams et. al (2006) had conducted the short term performance test, crude-degummed soybean oil and soybean ethyl ester were found suitable substitutes for diesel fuels. **Blends of biodiesel and conventional** hydrocarbon-based diesel are products most commonly distributed for use in the retail diesel fuel marketplace (Y Rekhu, 2011). Much of the world use a system known as the “B” factor to state the amount of biodiesel in any fuel mix:

- 100% biodiesel is referred to as B100, while
- 20% biodiesel, 80% petroleum diesel is labelled B20
- 5% biodiesel. 95% petroleum diesel is labelled B5
- 2% biodiesel, 98% petroleum diesel is labelled B2

Blends of 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications 6 (Biodiesel Handling and Use Guide, 2009), although certain manufacturers do not extend warranty coverage by the ASTM specification (Kuhn, 2009). Biodiesel can also be used in its pure form B100, but may require certain engine modifications to avoid maintenance and performance problems. Blending B100 with petroleum diesel may be accomplished by mixing in tanks at manufacturing point prior to delivery to tanker truck or splash mixing in the tanker truck by adding specific percentages of biodiesel and petroleum diesel and any other methods.

3.0 Methodology

3.1 Trans-Esterification

Biodiesel production is the process of producing the biofuel or biodiesel through the chemical reactions trans-esterification. Transesterification process used in production biodiesel. Methanol and Potassium Hydroxide (KOH) was used as a chemical for reaction. The coconut oil produce was mixed with the chemical to get the biodiesel. 3.5g Potassium Hydroxide (KOH), 100 Methanol and 500 ml coconut oil are used in production of biodiesel. Coconut oil was heat under medium temperature until it reach 100˚C. Wait until the heat coconut oil decrease around 60˚C. Then, mix 100ml and 3.5g KOH thoroughly and after that the coconut oil were placed in bottle sample. Mix the coconut oil with the mixing of methanol and catalyst and hake gently for 5 minutes. Finally, stand for 24 hours and the results shows biodiesel and glycerine.

3.2 Blend With Diesel

To compare the result with producing biodiesel by using transesterification, another one sample was using coconut oil by blend it with diesel. Coconut oil that produces form the coconut milk was blend with diesel and stand for 24hours to get the result.

3.3 Laboratory Test

3.3.1 Viscosity

Viscosity is the resistance of a fluid to flow. A fluid like honey that is very thick has a high viscosity and a fluid like water that is relatively thin has a low viscosity. First step to do is filled the oil in graduated cylinder to the 1000ml mark. And then, measure the length of the column of oil in meter and record the length. Take the temperature of the liquid at room temperature in (˚C) and record the data. Drop the Teflon ball into oil while using stopwatch to time from when the ball enters the oil to when it hits the bottom of the cylinder. Conduct total of three trials and record the times in seconds. The next is pour the liquids from the cylinder into the flask until it emptied most of the fluid and before the ball drops, place a sample of steel wool into a funnel to catch the balls. Heat the flask on the hot plate to a temperature of 60 ˚C, mix with stirring rod to meet the required temperature and repeat the step before.

3.3.2 Burning Test

Burning test be made because of to make sure the biodiesel that were produced are flammable and can be directly use in engines. Another reason for doing burning test is to either biodiesel can burning or not with the same volume and time with diesel. It is also to see the smoke resulting from the combustion.

3.0 Result

3.1 Results obtained

This chapter discussed about the results and experimental test during the project work. The tests were carried out to test the physical characteristics of coconut oil biodiesel and B20 based on the American Society for Testing and Materials (ASTM D6751). All tests were carried out at Environmental Laboratory except for kinematic viscosity. Laboratory scale quantities of coconut oil biodiesel produced through transesterification process gave results presented in Table 3.1. The table also shows the reaction conditions for the production process. Table 3.2 shows physical/fuel characteristics of coconut oil, coconut oil biodiesel and B20.

Table 3.1: Results for the transesterification process

Experimental Conditions	Quantities
Reaction temperature (°C)	100
Reaction time (hour)	24
Coconut oil quantity (g)	500
Methanol quantity (g)	100
KOH quantity (g)	3.5
Coconut oil biodiesel obtained (g)	400
Glycerol obtained (g)	100
Biodiesel yield %	80%

The transesterification process yielded 80% coconut oil biodiesel and 100g of glycerol. As a result of the low yield of the coconut biodiesel recorded, a blend was produced. Comparison of the physical characteristics of the coconut oil, coconut oil biodiesel and

$$\text{Biodiesel yield \%} = \frac{\textbf{Amount of biodiesel}\ \text{produced}}{\quad} \times 100$$

the blend are made in Table 3.2:

Table 3.2: Physical Properties of varies samples

Samples	Coconut oil	Coconut oil biodiesel	Coconut oil biodiesel blend with petroleum diesel
Viscosity at room temperature 40°C (mm^2/s)	43.3	4.5	6.3
Density (g/ml)	0.903	0.765	0.699

The table shows the experimental conditions for transesterification process from the very beginning until the end of the results obtained. The reaction temperature was 100°C. The increase in temperature of any simple reaction is expected to increase the reaction rate. However, in the catalytic bimolecular reversible reaction, the effect of temperature on forward and backward reactions may be different and it is necessary to find a temperature which gives the best results. The reaction time for the process was 24 hours as the temperature increases, the reaction rates increases and biodiesel yield was at maximum (80%) at 24 hours after a result of evaporation of methanol. The influence of temperature in this case displays an interesting behaviour. The higher the temperature, the more biodiesel was obtained with 200 ml of methanol. It works in the same direction as the previous assumption that a combination of increased acidity and high temperatures affects negatively the reaction of transesterification, favouring saponification and other side reactions. Eevera et al. (2009) realized that temperatures above an optimum value also favour side reactions along with other variables that might be taken into account. So it is not possible to define a general behaviour for temperature as its influence must be analysed in addition to the effect of other variables.

3.2 Kinematic Viscosity & Density

Kinematic viscosity was measured using ASTM D445 method. As for the properties of biodiesel, the lower heating value, higher density and higher viscosity play primary role in engine fuel consumption for biodiesel. Most of authors, who agreed that fuel consumption increased for biodiesel compared to diesel, contributed to the loss in heating value of biodiesel. Of course, some authors (E., 2010) only explained the increased fuel consumption as the result of higher density of biodiesel, which causes the higher mass injection for the same volume at the same injection pressure. And this argument also cited by authors in some other journal (Karabektas, 2009). However, some authors interpreted the increase in fuel consumption of biodiesel because of combination of properties of biodiesel. For example, it is attributed to lower heating value and higher density in to the combined effect of higher viscosity and lower heating value of biodiesel in, and to the interaction of higher density, higher viscosity and lower heating value of biodiesel in literatures (Utlu A., 2008).

Weight of oil used

Sample	Coconut Oil	Coconut oil biodiesel	Coconut oil biodiesel blend with petroleum diesel
Kinematic viscosity at room temperature 40°C (mm^2/s)	43.3	4.5	6.3
Density (g/ml)	0.903	0.765	0.699

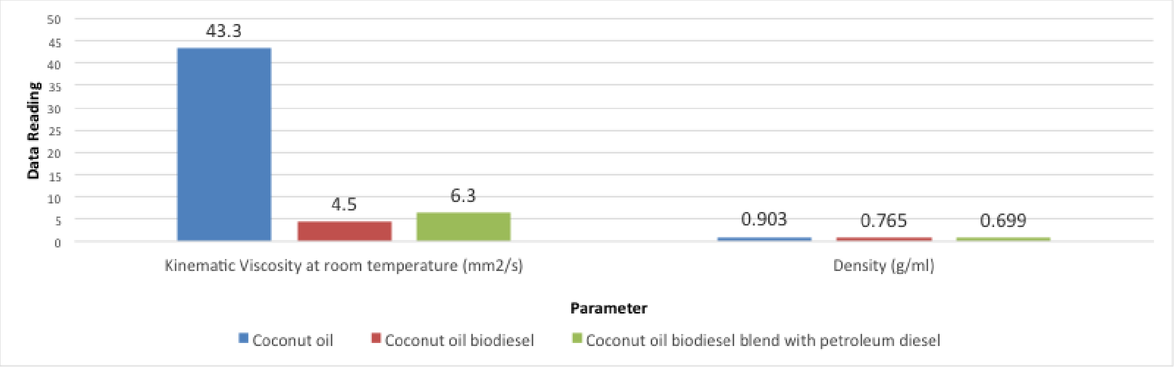

Figure 3.1: Kinematic viscosity & Density against Types of Sample

From the figure 3.1, it is observed that the viscosity of the coconut oil is very high which 43.3 mm2/s is. This is consistent with reported results on vegetable oils. As pointed out in earlier works carried out by (Peterson C. L., 1990) and (Alamu O. J., 2007), high viscosities of pure vegetable oils reduces the fuel atomization and increase fuel spray penetration, which would be responsible for high engine deposits and thickening of lubricating oil that cause injection coking and ring stickening of the engine and therefore compromising the efficiency of the engine (Raghavan, 2010). For the density, it showed that coconut oil is higher (0.903) than the coconut oil biodiesel and the blend. Also, it is seen from Table 2 that the blend density (0.699) is less than that of the coconut oil (0.904). It has been reported that, density of water is 1. So, as stated that the density of the coconut oil biodiesel and its blend is denser than water.

4.0 Conclusion

Vegetable oils can be used as fuel for combustion engines, but its viscosity is higher than usual diesel fuel and requires modifications of the engines. Therefore, vegetable oils are converted into their methyl esters (biodiesel) by transesterification. The viscosity value of vegetable oils is 43.3 mm^2/s. The viscosity values of vegetable oil methyl esters was highly decrease after transesterification process. There was a slightly decrease in density from 0.903 mg/ml to 0.765. Thus, both of biodiesel and B20 are flammable through burning test that were held.

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