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PRODUCTION OF BIODIESEL AS AN ALTERNATIVE FUEL

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ABSTRACT
Many researchers have successfully worked on generating energy from different alternative sources including solar and biological sources such as the conversion of trapped energy from sunlight to electricity and conversion of some renewable agricultural products to fuel. This work considers the use of coconut oil for the production of alternative renewable and environmental friendly biodiesel fuel as an alternative to conventional diesel fuel. Test quantities of coconut oil biodiesel were produced through transesterification reaction using 1000gm coconut oil, 20.0% methanol (wt% coconut oil), 0.8% potassium hydroxide as catalyst at 65°C reaction temperature and 30 minutes reaction time. The experiment was carried out three times and average results evaluated. Low yield of the biodiesel was obtained. The coconut oil biodiesel produced was subsequently blended with petroleum diesel and characterized as alternative diesel fuel through some ASTM standard fuel tests. The products were further evaluated by comparing specific gravity and viscosity of the biodiesel blend, the raw bio fuels and conventional petroleum diesel.

Keywords: Biodiesel, Blend, Petroleum diesel, Specific gravity, Viscosity

1. INTRODUCTION
Fuel and energy crisis and the concern of the society for the depleting world's non-renewable energy resources led to a renewed interest in the quest for alternative fuels. One of the most promising alternatives fuel is the vegetable oils and their derivatives. The first use of vegetable oil in a compression ignition engine was first demonstrated through Rudolph Diesel who used peanut oil in his diesel engine. The use of oils from coconut, soybean, sunflower, safflower, peanut, linseed, rapeseed and palm oil amongst others have been attempted. The long term use of vegetable oils led to injector coking and the thickening of crankcase oil which resulted in piston ring sticking. Therefore, vegetable oils are not used in SI engines because of endurance issues [1, 2].

To overcome this problem, various modifications of vegetable oils have been employed such as transesterification, micro-emulsion formation and the use of viscosity reducers. Among these, transesterification was considered as the most suitable modification because technical properties of esters are nearly similar to diesel. Through transesterification, these vegetable oils are converted to the alkyl esters of the fatty acids present in the vegetable oil [3-5]. These esters are commonly referred to as biodiesel. Biodiesel is an alternative fuel that is renewable in the sense that its primary feedstock has a sustainable source. Some other feed stocks that can be converted to biodiesel are waste restaurant grease and animal fat [6, 7]. These sources are less expensive than vegetable oil.

In view of the current instability in oil prices, biodiesel stands as an attractive source of alternative energy. By adopting and increasing the use of biodiesel, European countries have reduced from her over-dependence on crude oil reserves [8]. Besides, conventional fossil fuel has been reported as being finite. While it is worthy to note that biodiesel will not completely displace petroleum diesel, biodiesel has its place as an alternative fuel and can be a source of lubricity as an additive to diesel fuel. The emissions produced from biodiesel are cleaner compared to petroleum-based diesel fuel. Particulate emissions, soot, and carbon monoxide are lower since biodiesel is an oxygenated fuel. However, emissions of oxides of nitrogen (NO_X) are higher when biodiesel is used [9]. The cause of the rise in NO_X is unknown and is being studied.

One particular problem of biodiesel is its cold flow properties. Neat biodiesel such as methyl soyate has a pour point (i.e. the lowest temperature at which the fuel is pourable) of -3°C [1]. In colder climates, crystallization can occur, which leads to the plugging of fuel filters and lines. Typically, taking U.S as a case study, biodiesel is blended with diesel fuel. A B20 blend would be 20% biodiesel in diesel fuel [10]. Such a blend would have better cold flow properties compared to neat biodiesel. This work is therefore aimed at producing biodiesel from ethyl esters of coconut oil and comparing some properties of the produced biodiesel with ASTM standards

2. BIODIESEL

Biodiesel refers to a vegetable oil or animal fat-based diesel fuel consisting of long chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable, animal fat (tallow) with an alcohol.

2.1 Blends

Blends of biodiesel and conventional hydrocarbon-based diesel are products most commonly distributed for use in the retail diesel fuel marketplace. Much of the world uses 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% petro diesel is labeled **B20**
- 5% biodiesel, 95% petro diesel is labeled **B5**
- 2% biodiesel, 98% petro diesel is labeled **B2**

2.2 Transesterification Process

Coconut oil like any other vegetable oils and animal fats are triglycerides, inherently containing glycerin. The biodiesel process (transesterification) turns the oils into esters, separating out the glycerin from the main product (biodiesel). The glycerin sinks to the bottom and the biodiesel floats on top and can be decanted off. The process is called transesterification (as shown in fig.1), which substitute's alcohol for the glycerin in a chemical reaction, using a catalyst.

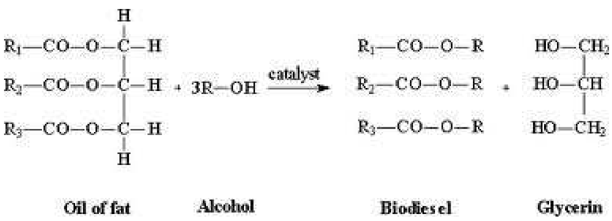

Fig 1: Transesterification chemistry for ethyl ester (biodiesel) production

2.3 Experimental Material

In the Laboratory scale production of coconut oil biodiesel, the following materials were used; 1 liter of coconut oil, 200 ml of methanol 99+% pure, sodium hydroxide (NaOH), blender, scales accurate to 0.1 grams, measuring beakers for methanol and oil, translucent plastic container with bung and screw-on cap, funnels, bottle for settling and washing, duct tape and thermocouple

The major feedstock source used in this work is coconut oil, locally produced in Bangladesh. It was purchased at the local market in kawran bazar Dhaka. By the stoichiometric equation of the process, 1 mol of coconut oil is required to react with 3 moles of methanol to produce 3 moles of the biodiesel and 1 mole of glycerol [11]. 100g coconut oil was used for the transesterification process. Reaction temperature for the process must be below the boiling point of alcohol (methanol, 78°C) used [12]; therefore, a reaction temperature of 65°C was selected. Different researchers have reported different reaction times for transesterification process as well as the entire biodiesel production process. The reported reaction time ranges from less than 15 minutes to more than 60 minutes [13]. Reaction time of 30 minutes was therefore selected.

Most researchers have used 0.1 to 1.2 % (by weight of oil) of catalyst for biodiesel production [13, 14]. 0.8% NaOH (by weight of coconut oil) concentration was therefore selected while 20% methanol was used. NaOH used was manufactured by a German company.

2.4 Experimental method and material:

Figure.2 shows the process of biodiesel production from coconut oil

- Step one :1000ml of coconut oil has been heated with heater at 65°c (as shown in fig.3)
- Step two: 200ml methanol and 3.5 gm NaOH has been mixed for making sodium methoxide.
- Step three : Then both heated oil with sodium Methoxide has been blending in a blender for 30 minutes for mixing. (As shown in fig.4)
- Step four: After that the mixture has been kept in a beaker for 24 hours. (as shown in fig.5)
- Step five: When biodiesel forms in the upper layer, it has been separated from waste (glycerin and soap)
- Step six: Then the biodiesel has been washed with distilled water in order to remove waste & a dry wash has been done by air stone.
- Step seven : Finally certain amount of diesel has been blend with biodiesel to produce B80, B50 and B30

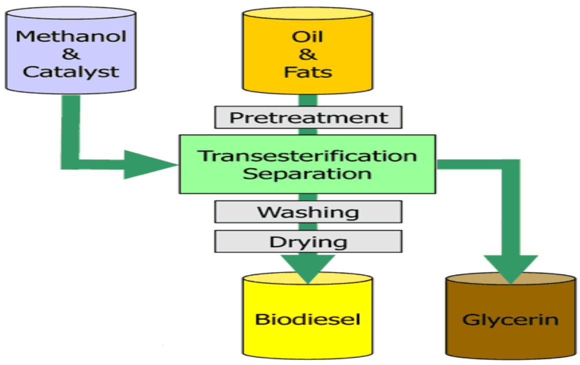

Fig 2: Flow diagram for biodiesel production from coconut oil

2.5 Washing method:

Washing has done in two steps:

- Step one: The collected biodiesel after Transesterification reaction has taken into a beaker. Hot water (40°C) has poured into the biodiesel slowly. Then the mixtures have shaken slowly and then kept the solution 4 hours in stable position. Then a layer of soap has formed in the bottom of beaker (as shown in fig.6). Then we collect the biodiesel by a pipe followed by siphoning method. We have repeated the process 4 times and gradually soap formation has reduced. We also measure the pH of the solution after each wash.

Table 1: For 1 liter Biodiesel (B-100)

Test Run	Watered Used (ml)	pH	Soap Formed
1st	200	9.67	High
2nd	200	9.37	High
3rd	200	8.84	Medium
4th	200	8.75	Low

- Step two: Dry wash: we used an air stone (as shown in fig.7) for producing bubbles in the solution for dry wash. We have seen soap formed during the action. Dry wash confirmed the formation of glycerol and soap rest in the mixture. We use a heater which has kept always 35°C for removing the water from biodiesel. After the process we finally collect the biodiesel (as shown in fig.8) and have tested its properties in the laboratory.

Fig 3: Heated bio-fuel

Fig 4: Blending process

Fig 5:After blending

Fig 6: Wet wash

Fig 7: Dry wash process

Fig 8: After washing

3. CHARECTERISTICS ANALYSIS:

We have tested the density, viscosity, calorific value, flashpoint etc properties of coconut oil, soybean oil, rapeseed oil, bio-diesel and also diesel to compare the characteristics.

Properties of tested oil are given bellow:

Table 2: Results for characteristics test of pure Bio fuel such as soybean oil, coconut oil, rapeseed oil.

Properties	Soybean	Coconut	Rapeseed
Viscosity at 40°c(mm^2/s)	35.36	30.37	36.35
Density	0.9293	0.9150	0.9213
Heat of combustion MJ /kg	37.23	39.56	36.12
Flash point (° C)	284	210	223
Ash content percent % (w/W)	0.17	0.02	0.01
Carbon residue (%w/w)	7.25	4.40	3.25

All properties have been tested in thermodynamics laboratory in MIST by using locally available bio fuel. All fuels have been filtered to remove unwanted particles from bio fuels before testing.

Table 3: Comparison of properties of biodiesel produced from coconut oil with respect to diesel fuel

Properties	Diesel	B100	B80	B50	B30
Viscosity (μ)at 40°c(mm^2/s)	2.94	6.51	5.87	4.72	3.93
Density	0.8126	0.8450	-----	-----	-----
Heat of combustion MJ /kg	45.71	40.37	41.44	42.97	43.13
Flash point (° C)	67	92	85	81	78
Ash content percent % (w/W)	0.0005	0.0045	-----	-----	-----
Carbon residue (%w/w)	0.17	0.05	-----	-----	-----

Table 4: Yielding analysis of bio diesel production.

Experimental Conditions	1st Run	2nd Run	3rd Run	Average
Reaction temperature (°C)	65	65	65	65
Reaction-time (min)	30	30	30	30
Coconut oil (gm)	100	100	100	100
Methanol (ml)	20.00	20.00	20.00	20.00
NaOH concentration (%)	0.80	0.80	0.80	0.80
Coconut-oil biodiesel-obtained (gm)	30.30	35.40	33.40	33.03
Glycerol obtained(gm)	41.70	44.20	45.40	43.77
Mass lost (gm)	28.00	20.40	21.20	23.30
Coconut oil biodiesel yield (%)	30.30	35.40	33.40	33.30

*by weight of 100g coconut oil

4. PERFORMANCE TESTING AND ANALYSIS:

We have made a preheating system in our diesel engine with the help of heater and thermo couple for measuring the temperature. A control unit is used to set temperature and automatic control of heater .Separate tank has used for directly use of coconut oil with mixing with diesel .single tank has used for testing biodiesel performance .a typical heater is used to preheat the oil both bio diesel and the direct using of oil .. For measuring BHP (Break Horse Power), we have used break type dynamometer. We only measured the BHP of the engine Diesel, B-100, B-80, B-50, B-30, pure coconut (20%) and diesel (80%), pure coconut (30%) and diesel (70%). Test has been run by varying rpm and fuel flow rate.rpm is measured by a digital tachometer. Fuel flow rate has varied to change the output results. We also vary the preheat temperature by using control unit.

Engine Parameter:

- Engine=single cylinder, 4stroke, air cooled,
- Rated R.P.M = 2600,
- Max output=3.23 KW,

Table 5: For preheating temperature 70 °c (except for diesel) and varying speed in rpm.

rpm / BHP	2245	2150	2055
Diesel (KW)	1.48	1.36	1.33
B-100 (KW)	1.12	1.05	1.01
B-80 (KW)	1.17	1.11	1.07
B-50 (KW)	1.27	1.16	1.11
B-30 (KW)	1.33	1.25	1.17
20% raw Coconut and 80% diesel (KW)	1.07	0.98	.0.91
30% raw Coconut and 70% diesel (KW)	0.97	0.87	0.73

Table 6: For constant rpm 2245 and varying preheating temperature.

Temp(°c) / BHP	70	65	60
Diesel (KW) Not preheated	1.48	1.48	1.48
B-100 (KW)	1.12	1.09	1.07
B-80 (KW)	1.17	1.14	1.11
B-50 (KW)	1.27	1.21	1.16
B-30 (KW)	1.33	1.31	1.24
20% raw Coconut and 80% diesel (KW)	1.07	1.01	0.98
30% raw Coconut and 70% diesel (KW)	0.97	0.93	0.87

5. EFFECT OF FUEL INJECTION OF RAW COCONUT OIL IN DIESEL ENGINE:

While using pure coconut oil in Diesel engine, it is very important to understand the difference between direct injection engine and indirect injection engine and the advantages that an indirect injection engine has over direct injection so that the engine is not damaged.

- Direct injection engine: The fuel is directly injected into the combustion chamber.
- Indirect injection engine: The fuel is injected into a pre-chamber which is connected with the cylinder through a narrow passage. Rapid air transfer from the main cylinder into the pre-chamber promotes a very high degree of air motion in the pre-chamber which is particularly conducive to rapid fuel air mixing. Combustion beginning in the pre-chamber produces high pressure and the fuels are subjected to high shear forces In order to avoid engine damage proper combustion of coconut oil in the combustion chamber has to be ensured. Improper combustion can result in carbon deposits on the nozzles and valves (as shown in Fig 9) and mechanical damage to the piston rings and cylinder (as shown in Fig 10).

Proper combustion of coconut oil in the chamber is ensured by:

- Decreasing the viscosity of the oil by heating it to around 70°C.
- Ensuring good atomization of the fuel by increasing injection pressure to 180 – 200 bar
- Ensuring that the temperature in the combustion chamber is high enough (above750°C).

Fig 9: Carbon deposits on Nozzle and valve

Fig 10: Mechanical damage in cylinders

6. ADVANTAGES OF VEGETABLE OIL:

In the field of vegetable oil usage, many advantages are noticeable which are as follows:

1. Vegetable oil is produced domestically which helps to reduce the cost of petroleum imports.
2. Development of the bio-diesel industry would strengthen the domestic and particularly the rural, agricultural based countries like India and Bangladesh
3. It is bio -degradable and non-toxic.
4. It is a renewable fuel that can be made from agricultural crops and/or other feed stocks that are considered as waste.
5. It contains low aromatics.
6. Low sulfur content and hence environment friendly.
7. Enhanced lubricity, thereby no major modification in the engine is required.
8. It is usable within the existing petroleum diesel infrastructure (with minor or no modification in the engine).[15]

7. CONCLUTION:

Study shows that cost of biodiesel production from coconut oil is comparatively higher than soybean and rapeseed, but energy output and fuel consumption rate is better. Besides that, coconut oil has better lubrication properties than other bio-fuels. Now a day, when developing countries are suffering deeply from energy crisis, Bio Diesel can be used as a promising alternative source. Although production cost of biodiesel is high but it is environment friendly and a good source of renewable energy. Detailed research is required to study the prospect of biodiesel in Bangladesh.

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9. NOMENCLATURE:

Symbol	Meaning	Unit
T	Temperature	° c
Q	Calorific value	(MJ/kg)
w/W	Specific gravity	-----
μ	viscosity	mm^2/s