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PRODUCTION OF BIODIESEL FROM WASTE VEGETABLE OIL

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Abstract:- *Biodiesel is gaining more and more importance as an attractive fuel due to the depleting fossil fuel resources. Chemically biodiesel is mono alkyl esters of long chain fatty acids derived from renewable feed stock like vegetable oils and animal fats. It is produced by trans esterification in which, oil or fat is reacted with a monohydric alcohol in presence of a catalyst. The process of trans esterification is affected by the mode of reaction condition, molar ratio of alcohol to oil, type of alcohol, type and amount of catalysts, reaction time and temperature and purity of reactants. In my project, I produced Biodiesel from waste vegetable oil by trans esterification process. Then, test the characteristics of my produced Biodiesel. Finally, I made a conclusion by comparing my produced Biodiesel with standard data and made it feasible in Bangladesh.*

Keywords: Waste vegetable oil, Trans esterification, Bio diesel, Petroleum derived diesel.

1. INTRODUCTION

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, ethyl, or propyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat (tallow)) with an alcohol producing fatty acid esters [1]. Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. Trans esterification of a vegetable oil was conducted as early as 1853by Duffy and Patrick [2], many years before the first diesel engine became functional [3]. Rudolf Diesel's prime model, a single 10 ft (3 m) iron cylinder with a flywheel at its base, ran on its own power for the first time in Augsburg, Germany, on 10 August 1893 running on nothing but peanut oil. In remembrance of this event, 10 August has been declared "International Biodiesel Day"[4]. It is often reported that Diesel designed his engine to run on peanut oil, but this is not the case. Diesel stated in his published papers, "at the Paris Exhibition in 1900 (*Exposition Universelle*) there was shown by the Otto Company a small Diesel engine, which, at the request of the French government ran on arachide (earth-nut or pea-nut) oil (see biodiesel), and worked so smoothly that only a few people were aware of it. The engine was constructed for using mineral oil, and was then worked on vegetable oil without any alterations being made. The French Government at the time thought of testing the applicability to power production of the Arachide, or earth-nut, which grows in considerable quantities in their African colonies, and can easily be cultivated there." Diesel himself later conducted related tests and appeared supportive of the idea. In a 1912 speech Diesel said, "the use of vegetable oils for engine fuels may seem insignificant today but such oils may become, in the course of time, as important as petroleum and the coal-tar products of the present time. "Despite the widespread use of petroleum-derived diesel fuels, interest in vegetable oils as fuels for internal combustion engines was reported in several countries during the 1920s and 1930s and later during World War II. Belgium, France, Italy, the United Kingdom, Portugal, Germany, Brazil, Argentina, Japan and China were reported to have tested and used vegetable oils as diesel fuels during this time. Some operational problems were reported due to the high viscosity of vegetable oils compared to petroleum diesel fuel, which results in poor atomization of the fuel in the fuel spray and often leads to deposits and coking of the injectors, combustion. On 31 August 1937, G. Chavanne of the University of Brussels (Belgium) was granted a patent for a "Procedure for the transformation of vegetable oils for their uses as fuels" (fr. "*Procédé de Transformation d'HuilesVégétales en Vue de LeurUtilisationcommeCarburants*") Belgian Patent 422,877. This patent described the alcoholysis (often referred to as transesterification) of vegetable oils using ethanol (and mentions methanol) in order to separate the fatty acids from the glycerol by replacing the glycerol with short linear alcohols. This appears to be the first account of the production of what is known as "biodiesel" today [5].More recently, in 1977, Brazilian scientist Expedito Parente invented and submitted for patent, the first industrial process for the production of biodiesel [6]. This process is classified as Biodiesel by international norms, conferring a "standardized identity and quality. No other proposed biofuel has been validated by the motor industry.

“As of 2010, Parent’s company Tecbio is working with Boeing and NASA to certify bio querosene (bio-kerosene), another product produced and patented by the Brazilian scientist [7]. Often biofuels are criticized in the media for their low production energy efficiency, environmental impacts and by using food for fuel production. An answer most critics rely on is stating how 2nd generations biofuels will solve all the problems the first generation biofuels possess. However, 1stgeneration biofuels must “pave the way” for 2nd generation biofuels. They can do this by providing the infrastructure, technology and knowledge provided by the fuels. In order to increase the efficiency of 1st generation biofuels, the theories of industrial symbiosis can be applied. Industrial symbiosis theories are designed to integrate production systems and other industries to improve energy efficiency and environmental performance. By integrating biofuel production systems, the by-products of biofuels can be used in subsequent processes. By making use of by-products, excess heat, etc. the energy efficiency can be improved and allow for more benefits including economic and environmental performance. Developed in the 1890s by inventor Rudolph Diesel, the diesel engine has become the engine of choice for power, reliability, and high fuel economy, worldwide. Early experimenters on vegetable oil fuels included the French government and Dr. Diesel himself, who envisioned that pure vegetable oils could power early diesel engines for agriculture in remote areas of the world, where petroleum was not available at the time. Modern biodiesel fuel, which is made by converting vegetable oils into compounds called fatty acid methyl esters, has its roots in research conducted in the 1930s in Belgium, but today’s biodiesel industry was not established in Europe until the late 1980s.

The diesel engine was developed out of a desire to improve upon inefficient, cumbersome and sometimes dangerous steam engines of the late 1800s. The diesel engine works on the principal of compression ignition, in which fuel is injected into the engine’s cylinder after air has been compressed to a high pressure and temperature. As the fuel enters the cylinder it self-ignites and burns rapidly, forcing the piston back down and converting the chemical energy in the fuel into mechanical energy. Dr. Rudolph Diesel, for which the engine is named, holds the first patent for the compression ignition engine, issued in 1893. Diesel became known worldwide for his innovative engine which could use a variety of fuels. The first public demonstration of vegetable oil based diesel fuel was at the 1900 World’s Fair, when the French government commissioned the Otto Company to build a diesel engine to run on peanut oil. The French government was interested in vegetable oils as a domestic fuel for their African colonies. Rudolph Diesel later did extensive work on vegetable oil fuels and became a leading proponent of such a concept, believing that farmers could benefit from providing their own fuel. However, it would take almost a century before such an idea became a widespread reality. Shortly after Dr. Diesel’s death in 1913 petroleum became widely available in a variety of forms, including the class of fuel we know today as “diesel fuel”. World War II and the oil crises of the 1970’s saw brief interest in using vegetable oils to fuel diesel engines. Unfortunately, the newer diesel engine designs could not run on traditional vegetable oils, due to the much higher viscosity of vegetable oil compared to petroleum diesel fuel. A way was needed to lower the viscosity of vegetable oils to a point where they could be burned properly in the diesel engine. . It was a Belgian inventor in 1937 who first proposed using trans esterification to convert vegetable oils into fatty acid alkyl esters and use them as a diesel fuel replacement. The process of trans esterification converts vegetable oil into three smaller molecules which are much less viscous and easy to burn in a diesel engine. Pacific Biodiesel became one of the first biodiesel plants in the United States in 1996, establishing a biodiesel production operation to recycle used cooking oil into biodiesel on the island Maui in Hawaii. The biodiesel industry became a household name in the U.S. after the terrorist attacks of 9/11/2001 resulted in historically high oil prices and an increased awareness of energy security. As of 2005, worldwide biodiesel production had reached 1.1 billion gallons, with most fuel being produced in the European Union, although biodiesel projects worldwide have been on the rise due to rising crude oil prices and concerns over global warming. Since the shortage of motor fuel, considerable attention has been paid to finding substitutes from sources other than petroleum. Vegetable oil/animal fats are known to be effective diesel substitute but their high viscosities relative to diesel oil give rise to poor atomization leading to engine and injector deposits, and also injector pump failure. Methyl and ethyl esters of various vegetable oils/animal fats are indeed effective diesel oil substitutes and because of their lower viscosity appear to be superior to the parent vegetable oil. Biodiesel has been vigorously and independently tested in virtually every type of diesel engines by a vast number of agencies, both in laboratory and on the road. The US National Biodiesel Board (NBB) reports the tests combine to account for over 50-million street miles plus intense off-road and marine use.Performance is estimated to be comparably to petroleum in all areas, from power to efficiency and from hauling to climbing. It can be used in its pure form or blended with petroleum fuel.The common international standard for biodiesel is EN 14214. Biodiesel provides easy adjustment for most modern diesel engines, the transformation is rather easy. Car and heavy vehicle manufacturers such as Audi, Daimler Chrysler and Volvo are producing engines which can operate using pure biodiesel (8100), without any additional modification. And, as it is for blended biodiesel, all modern diesel engines can operator using some shares of blended fuel without any modification: these include lorries, trains,public transport, marine vessels etc.

2. METHOLDOLOGY

To make biodiesel fuel efficiently from waste vegetable oils and animal fats we have to avoid one major problem: soap formation. Soap is formed during base- catalyzed trans esterification (using lye) when sodium ions combine with free fatty acids present in used vegetable oils and animal fats. The soaps diminish the yield because they bond the methyl esters to water. The bonded esters get washed out at the washing stage but make water separation more difficult increase water consumption.

This process is trans esterification [8] similar to saponification. Saponification is soap making. To make soap, it requires a trans fatty acid or triglyceride (oil, fat, or kitchen grease) and then blending it with a solution of sodium hydroxide (NaOH, caustic soda) and water. This reaction causes the ester chains to separate from the glycerin. These ester chains are what the soap becomes. They are also called lipids. Their unique characteristics of being attracted to polar molecules such as water on one end and to non-polar molecules like oil on the other end is what makes them effective as soap.
In trans esterification, KOH and ethanol are mixed to create sodium meth oxide ($Na^{+}CH_3O$). When mixed in with the WVO/fat this strong polar bonded chemical breaks the trans fatty acid into glycerin and also ester chains (biodiesel).
The experimental setup for biodiesel production is shown below:

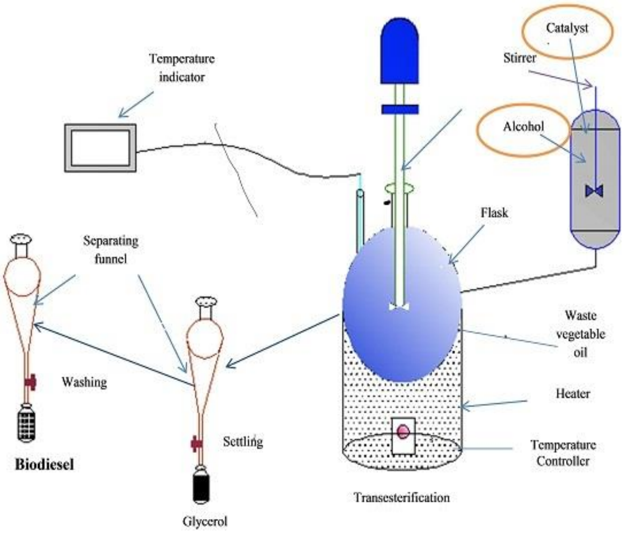

Fig.1: Experimental setup for biodiesel production

The experimental procedure of making biodiesel from trans esterification process are given below:

l. Filtering the WVO (waste vegetable oil) to remove any food scraps or solid particles.

2. Heating the WVO to remove any water content (optional).

3. Performing titration to determine how much catalyst is needed.

4. Preparing potassium ethoxide.

5. Heating of WVO, mixing the potassium ethoxide while stirring.

6. Settling & remove the glycerin.

7. Washing and drying.

8. Checking the quality**.**

9. Comparing with standard characteristics.

3. COLLECTED DATA

Table 1: Quality test

Name of the test	Reading	Standard value	Comments on quality
Wash test	Exists a thin layer between oil and water	Exists a thin layer between oil and water	medium
Ethanol test	From a moderate bright phase	From a strong bright phase	medium
Viscosity test	40.6@ 28^{0}C 20.55@ 40^{0}C 10.08@ 60^{0}C	20.55-30@ 40^{0}C	medium

4. RESULTS AND DISCUSSION

Biodiesel can be obtained from palm oil or vegetable oil. But the rate of production of biodiesel from WVO is much less than that from palm oil. It requires large amount of WVO to get an appreciable amount of biodiesel. For example – from 200 ml of WVO you can get only 4-5 ml ester. So, it’s intelligent not to use WVO for the large production of biodiesel but for only laboratory use. An important objective of this work is to find out whether esters could be conveniently synthesized at room temperature, and although many of the experimental conditions tried in this work required elevated temperatures to effect reaction, eventually successful conditions at room temperature are found by systematically optimizing the variables. The main variables are catalyst, catalyst concentration, rapeseed oil, alcohol ratio and stirring rate.
The specific fuel consumption of the fuels is in the following increasing order: diesel oil, methyl ester, rapeseed oil, ethyl ester. The methyl ester is only 10% less efficient than diesel oil.
Exhaust residues for methyl and ethyl ester are greater than for diesel oil, but not as great as for rapeseed oil, showing that esterification leads to definite improvement.
Deposits on cylinder walls and injectors are appreciable for both methyl and ethyl esters even on short runs.
Both methyl and ethyl ester lead to decreased viscosity of lubricating oil within five hours due to blow-by of unburnt fuel in the cylinders. This would create a definite problem if the viscosities are allowed to continue to decrease. Other workers observed the same difficulty with esters of soybean oil (14. Blackburn, Pinchin, Norb, Crichton, Cruse, 1983), and also that the potential problem of eventual increased viscosity due to polymerization did not ensure until much later.
Biodiesel does have some limitations. First it has cold-weather starting problems. Depending on the type of oil used, around 40 degree F (4-5 degree c) it may start to

solidify. One remedy is to mixing with proportion of fossil diesel. Or trying to rancor or Diesel-thermoelectric fuel heater. Heated garages are nice too. Some people report that standard ant gelling compound work fine, others say they're unpredictable.

Another cold-weather idea is the two-stage method recommended by Alekskac. He has found that doing the reaction this way leaves him with a fuel that works better in colder conditions.

Retarding the injection timing by 2-3 degree – this overcomes some of the effect of the biodiesel's higher octane number. The engine losses a bit of the extra power that got with biodiesel, but it runs quieter and fuel burns cooler reducing NOx emissions.

There can be an increased rate of corrosion of rubber parts in the fuel system over time with 100% biodiesel. Newer cars do not use rubber parts. Biodiesel has been used in many older motors without any problems.

5. STORAGE CONDITIONS FOR BIODIESEL

Biodiesel can be stored for long periods of time in closed containers with little headspace. The containers should be protected from weather, direct sunlight and low temperatures. Avoid long term storage in partially filled containers, particularly in damp locations like dock boxes. Condensation in the container can contribute to the long-term deterioration of the petroleum diesel or biodiesel. Low temperature can cause the Biodiesel to get, but the Biodiesel will quickly liquefy again as it warms up. In cold weather, additives can be used to prevent gelation.

Fuel tanks should be kept as filled as possible (regardless of whether they contain Biodiesel), particularly during rainy winter months or periods in inactivity, to minimize the condensation of moisture. Condensed moisture accumulates as water in the bottom of the storage tank and can contribute to the corrosion of metal fuel tanks, especially with petroleum diesel that contains sulfur. The condensed water in the fuel tank can also support the growth of bacteria an mold that use the diesel and Biodiesel hydrocarbons as a food source. These hydrocarbon-degrading bacteria and molds will grow as a film or slim in the tank and accumulate as frequently referred to incorrectly as "algae" in advertisements for fuel treatments, perhaps because the colonies often have a reddish orange color and tend to form mats.

Biodiesel should be stored in clean dry tanks. Though the flash point of biodiesel is high, still some storage precautions are needed to be taken. It can be stored for long periods in closed containers with little head room but the container must be protected from direct sun light, low temperature, and weather. Underground storage is preferred in cold climates, but low temperature can cause biodiesel to gel. The biodiesel or its blends should be stored at temperature of at least 15 °C higher than the pour point of the fuel. While blending the biodiesel care should be taken to avoid very low temperatures as the saturated compounds can crystallize and separate out to cause plugging of fuel lines and filters.

6. CONCLUSIONS

In the current investigation, it has enabled us to confirm that waste vegetable oil may be used as a resource to obtain biodiesel. JOME and ROME has become more attractive to replace petroleum fuel. As per the literature study, most of the trans esterification studies have been done on edible oils like rape seed, soy bean, sun flower, and canola by using methanol and NaOH /KOH as catalyst. Waste vegetable oil is one of the most potential source to produce biodiesel in India, which could offer opportunities for generation of rural employment, increasing income and improving environment. The above experimental result reveals the alkaline catalyzed trans esterification was a promising area of research for production of biodiesel in large scale. best among the others in this experiment.

The comparison of more properties of biodiesel with diesel will be good before using it in the engine. In a comparison test of diesel fuel, fuel grade methyl esters and palm oil, the fuel grade methyl esters will give the performance near about the performance of diesel fuel. If anyone can run an engine over a period of time using produced biodiesel to check the perfect working capacity of the engine, then it will give a good result. Below the temperature of 4-5 ^{0}C, the formation of crystals in fuel grade methyl esters occurs which is a great problem. It's not a reliable low temperature fuel. Storage of methyl esters have to be indoor or in underground.

7. SUGGESTION FOR FURTHER STUDY:

In my experiment, I used WVO (waste vegetable oil)to produce biodiesel. The amount of biodiesel from WVO was so small in comparison with the same amount of palm oil. WVO contain large amount of saturated fatty acids and so the production rate of biodiesel is small. During separation of glycerol and biodiesel, care should be taken that there is no glycerol in the biodiesel layer. Because excessive glycerol cause damage to engine while using the biodiesel to run the vehicles. So it should be noted that when any one wants to make biodiesel he must choose the proper source such as palm oil.

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