BIODIESEL PRODUCTION USING SOLAR ENERGY

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Abstract: *Due to the decrease of oil reserve it has been searched a new category of energy, obtained from renewable sources. Biodiesel is an attractive replacement for depleting energy sources since it is produced from vegetable oils or animal fats, it is non-toxic and is a renewable resource. To obtain biodiesel is necessary to heat a triglyceride with an alcohol (usually methanol or ethanol). For heating the mixture it is used electricity obtained from fossil resources. In this study is proposed to use the solar energy for heating the mixture using a parabolic reflector. By this method, the emission of carbon dioxide during the biodiesel fabrication process is reduced.*

Keywords: *biodiesel, solar energy,*

1. INTRODUCTION

The world's energy production for vehicles propulsion is based on fossil fuels from coal, crude oils and natural gas. If the global consumption will remain constant, it is estimated that in 30 years the reserve of fossil fuels will be finished [1]. A solution to this problem is that it is needed to use new fuels that are developed from renewable sources. An example of renewable sources is vegetable oil. The crops that are used to obtain the oil can be regenerated periodically. For this reason the vegetable oils can be considerate a renewable fuel sources whose supply will never run out.

Biodiesel is the methyl ester of vegetable oil and is a clean burning, diesel fuel replacement that is an exact substitute for existing compression engine [2]. It can be used in engine as a pure fuel or as a blended mixture with diesel fuel (in any percentage).

The oil can be obtained from various oil plants, with oil production averaging between 5000 kg oil/hectare to 145 kg oil/hectare (Table 1) [3].

Table 1. Oil production averages

Plant	kg oil/hectare
Oil palm	5000
Coconut	2260
Jatropha	1590
Rapeseed	1000
Peanut	890
Sunflower	800
Hemp	305
Corn	145

Some of these plants can be harvested more than once a year, increasing the oil production.

Biodiesel is the alkyl esters that are synthetized from a transesterification reaction on vegetable oils. The transesterification reaction can be catalyzed by either acids or bases the most common means of production is base-catalyzed transesterification. This path has lower reaction times and catalyst cost than those posed by acid catalysis. However, alkaline catalysis has the disadvantage of its high sensitivity to both water and free fatty acids present in the oils. To prepare biodiesel the vegetable oil, alcohol and base have to be mixed together while being heated. Usually, the heating is made using electricity who is generated from fossil fuels. To make the synthetic production of biodiesel more sustainable, alternative heating sources must be developed.

The alcohol used in the transesterification reaction to produce biodiesel is methanol or ethanol. Methanol is produced by destructive distillation of wood. Industrial methanol is produced in a catalytic process directly from carbon monoxide, carbon dioxide and hydrogen. Methanol when drunk is metabolized first to formaldehyde and then to formic acid or formats salts[4]. These are poisonous to the central nervous system and may result in blindness, coma, and death. Ethanol is another alcohol used in the transesterification process. Ethanol is produced by the fermentation of sugars by yeasts or by petrochemical processes. Ethanol is much less poisonous to the central nervous system and is safe for human consumption in moderation at diluted concentrations.

Glycerol is produced in the transesterification process. For every liter of biodiesel produced 125 grams of glycerol is produced [5]. Pure glycerol is used to make products like solvents and preservatives in food industry, pharmaceutical products, personal care products.

This glycerol contains unreacted alcohols, unreacted base, water and salts. For use in industry the glycerol has to be purified. To remove alcohols and water traces the crude glycerol must be heated to boiling. To make this refinement process sustainable must be reduced the amount of energy required to purify the glycerol from the production of biodiesel.

The goal of this study is to make biodiesel without electricity obtained by fossil fuels. A solar reflector was used to heat the biodiesel container and synthesize biodiesel. This reaction was chosen based on its current use in synthesis processes used in industry. Methanol has been used as reaction alcohol. The obtained glycerol is purifying using solar heating.

2. TESTS AND RESULTS

A solar reflector was made using a satellite dish with a diameter of 70 cm. The dish was covered with reflexive paint and transform into a reflexive parabolic mirror that generate heat. The feed horn of the dish was remove and replaced by reaction flasks. The feed horn was placed in the focal point of the mirror and the flask achieve the maximum intensity of sunlight.

To test the viability of the method, two tests were made: one with a 100 ml of vegetable oil and another with 1 liter of vegetable oil.

In the first case (100 ml) was combined 100 ml sunflower oil with 50 ml of methanol and 1 g of sodium hydroxide and swirling the mixture for about four minutes in a 250 ml round flask. The flask was heated by solar radiation for 90 minutes.

In the second case (1 liter) was combined 1 liter of sunflower oil with 500 ml of methanol and 10 g of sodium hydroxide. The mixture was swirling for four minutes in a 2000 ml round flask. The flask was heated by solar radiation for two hours.

In both cases the temperature of mixture was between 70 and 75^{o}C.

After exposure at solar radiation, the flasks was moved and the solutions were cooled at the ambient temperature. During this time it was formed two layers. The top layer was biodiesel and the bottom layer was crude glycerol.

In first case was obtained 95.5 g (94.6%) of biodiesel, and in the second case was obtained 934.3 g (92.5%) of biodiesel.

Data obtained from the synthesis using the heat from solar irradiation concluded that the solar heat source provided an efficient alternative heating source. The biodiesel product yields were similar with the yield obtained in the laboratory (Table 2). These results shows that the heat exchange is equivalent in both methods.

There are some factors that influence the efficiency. On cloudy days is not sufficient solar irradiation to produce enough energy to heat the mixture. The passing clouds affect the process of heating. By increasing the volume of mixture, the larger mass was capable to keep the heat for a longer period of time.

Table 2. Comparison of yields for biodiesel production

	Yield, %	
Vegetable oil, ml	Solar heating	Laboratory
100 ml	94.6	97.3
1000 ml	92.5	95.8

Season and outside temperature had effect about the heating process (Table 3).

Table 3. Seasonal variation

	Spring	Summer	Autumn	Winter
Time to begin reflux	13	4	7	6
Reflux temperature	74^{o}C	77^{o}C	76^{o}C	74^{o}C
Average outside temperature	14^{o}C	28^{o}C	22^{o}C	4^{o}C
Outside conditions	Cloudy	Sunny	Few clouds	Cloudy
Percent yield	91%	96%	95%	92%

Using a small probe of mixture of vegetable oil and methanol were made test to check the yield percent of biodiesel for each season. The colder outside temperature in spring and winter gave the advantage of keeping the condenser cooler than in the summer and autumn. By lower temperature of cooler more of excess methanol was able to be recovered .

No electricity was used during the process of biodiesel production and glycerol purification. All heat used to produce biodiesel and distill methanol from recovered glycerol was generated using the sunlight.

Using a power meter it was determined, in laboratory, the energy (in kWh) used to obtained the biodiesel and to purify the glycerol obtain after the biodiesel process.

It was determined that for heating the mixture up to 70^{o}C it is consumed 0.4 kWh and for purification of glycerol it was used 0.2 kWh. Thus, the total energy used to obtain biodiesel and clear glycerol was 0.6 kWh.

According to "Greenhouse gas reporting" [5] for the production of one kWh is emitted 0.41 kg CO2. Thus, the 0.6 kWh of energy generates 0.246 kg CO2. By using the sunlight radiation the greenhouse gas emissions are being eliminated.

The glycerol purification process recovers any trace of alcohol that can be used in subsequent operations. During the glycerol recovery process are generated free fatty acids, which can be used to synthesize more biodiesel.

For drying the biodiesel is used sodium sulfate and is obtained waste. If the biodiesel is stored several days, the water can be removed without sodium sulfate as a drying agent. The water and biodiesel will form two layers, and the water can be removed and the pure biodiesel is obtained.

3. CONCLUSIONS

This work demonstrated that the solar heat source can replace the electric heating source. The outside temperature influences the process of glycerol purification.

Biodiesel was successfully obtained without wastes. Any unreacted alcohol was recovered and the recovered free fatty acid was used to obtained more biodiesel. Waste glycerol was recovered and purified and can be used for another applications.

By using the solar heating no electricity was used, and the greenhouse gas emissions for producing biodiesel and purifying glycerol was 0.

For this dish it can be obtained about 4 liters of biodiesel/day. In the future, plans are to test a larger dish to see the if the process can be implemented into industrial reactions.

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