Journal of Petroleum & Environmental Biotechnology
ISSN: 2157-7463

Udeh, J Pet Environ Biotechnol 2017, 8:2
DOI: 10.4172/2157-7463.1000321

Research Article | Open Access

Biodiesel Production from Waste Vegetable Oil (Sunflower) Obtained from Fried Chicken and Plantain

Benard A Udeh*

Faculty of Environmental Engineering, Department of Environmental Sciences, Cyprus International University, Haspolat, Nicosia, Turkey

Abstract

Waste sunflower oil sourced from fried chicken and plantain was used for biodiesel production in this study. During the transesterification process, 161 ml of ethanol containing 96% (v/v) was added to 250 ml of waste sunflower oil using NaOH as the catalyst at different concentrations (2.0% to 4.0%) and temperatures (45°C, 60°C, 70°C and 85°C). Biodiesel yield of 88.6% was obtained at the temperature of 70°C in 3.0% NaOH. Viscosity test at room temperature and specific gravity evaluation recorded 2.81 cm^2s^{-1} and 0.912 Kg/m^3 respectively. The high energy density obtained from waste sunflower biodiesel blend is comparable with the hydrocarbon-based fossil fuel, an indication for smooth engine runs. This means that waste sunflower oil could be a veritable material for energy production as the alternative to greenhouse issues of fossil fuel diesel blend.

Keywords: Biodiesel; Trans-esterification; Waste; Sunflower oil; Energy

Introduction

Trans-esterification and esterification are chemical processes used in the production of biodiesel/or biofuel from animal fats/oil [1]. Biodiesels can be produced from vegetable oil, animal fats and cooking oil, it is biodegradable, non-toxic and has few emissions when compared to fossil fuel based product. As fossil fuels are depleting year after year, the emergence of new technologies should be paramount in order to produce fuel from waste and renewable biomass [2].

In early 1970's acute fuel shortage culminated diversifying fuel resources and thus biodiesel as fatty esters were developed as alternatives to petroleum diesel. Afterwards towards 1990's there was a kind of relieve from atmospheric pollution from fossil fuel-based diesel and interest started rising on the use of trans-esterification and esterification alternative. Nowadays, diesel engines require cleaner burning, the stable fuel that will operate under a variety of conditions [3]. However, the resurgence of biodiesel from waste and animal fats has been affected by regulations and legislations in different countries in order to minimize pollution and to rule out the competition with food industries. Many of the regulations and laws are centered on promoting the countries agro-economy, national security and reducing climate change.

Trans-esterification is a technique used in the soap industries for soap and detergent production in many industries. Biodiesel is produced in a similar chemical process as soap using base-catalyzed trans-esterification as it is the most economical process, requiring very low temperatures and pressures while producing 98% conversion yield [4].

During trans-esterification process, the fatty acid /glyceride is reacted with alcohol in the presence of a catalyst, usually a very strong alkaline such as potassium hydroxide or sodium hydroxide [5,6]. Alcohol reacts with the fatty material in the presence of a catalyst to form biodiesel or mono-alkyl ester and glycerol. A successful trans-esterification reaction is characterized by separation of methyl ester (biodiesel) and glycerol layers after the reaction [7]. Heavier co-product, glycerides settles at the bottom, while the lighter one biodiesel occupies top. The solid part, glyceride may be collected and sold for other industrial uses, in cosmetics, detergents or pharmaceuticals. Crude glyceride phase which is left after trans-esterification may require purification prior to use [7].

In this study, ethanol was used and catalyzed with sodium hydroxide to form biodiesel and crude glyceride that is soapy in nature aimed to produce biodiesel fossil fuel alternative blend that is carbon neutral with smoke-free engines. The product yield according to literature is less than 10 percent (10%) carbon dioxide only, with no other gasses emissions that could be seen in fossil fuel-based diesel blend [8]. Low amount of carbon dioxide released could be used by green plants for process metabolism during photosynthesis. These will reduce to barest minimum greenhouse issues/other gaseous contaminants of long-accumulated flora and fauna fossil fuel biodiesel made products in industrial uses, in cosmetics, detergents or pharmaceuticals and perhaps will minimize the current issue of climate change that is ravaging global economy at the moment. Crude glyceride phase which is left after trans-esterification may require purification prior to use [7].

Material and Methods

Raw materials and chemicals

5 liters of waste vegetable oil was collected from a restaurant in Cyprus international university and kept at a room temperature for one day to enable settling. Thereafter, 1 liter was collected and filtered to remove impurities, then heated to rule out the presence of water and kept for further investigation. Ethanol 96% (v/v) and between (2.0% to 4.0%) sodium hydroxide that were laboratory stored was used in this study as the catalyst.

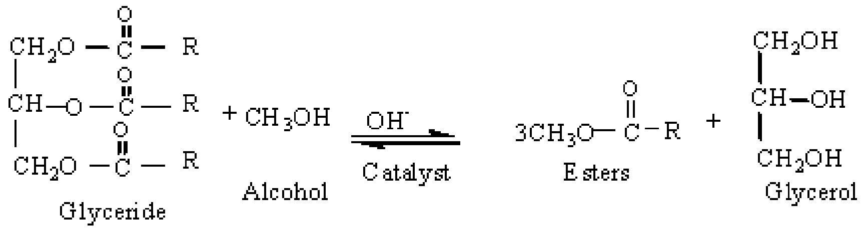
Purification

One liter of the waste sunflower oil sample was allowed to pass

***Corresponding author:** Benard A Udeh, Faculty of Environmental Engineering, Department of Environmental Sciences, Cyprus International University, Haspolat, Nicosia, Turkey, Tel: +905428788169; E-mail: becbenarcsudeh@gmail.com

Received March 08, 2017; **Accepted** March 30, 2017; **Published** Apriil 17, 2017

Citation: Udeh BA (2017) Biodiesel Production from Waste Vegetable Oil (Sunflower) Obtained from Fried Chicken and Plantain. J Pet Environ Biotechnol 7: 321. doi: 10.4172/2157-7463.1000321



Source: www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_biodiesel.htm

Figure 1: Process application of ethyl ester biodiesel.

Time (Minutes)	Temp (°C)	NaOH % (w/v)	Oil (w/w)	Ethanol (v/v)	Biodiesel yield (%)
120	45	2	250	161	35.2
180	60	2.5	250	161	52.1
240	70	3	250	161	88.6
300	80	3.5	250	161	87.8
340	85	4	250	161	62

Table 1: Evaluation of biodiesel yield (%) during ethanol, waste sunflower oil trans-esterification at different temperatures, time and catalyst (NaOH) concentration.

through a sedimentation tank for purification. Then filtered, residue weighed and kept for further investigation. About 1 liter of the sample was weighed and then heated to a temperature of 105°C for 2h in order to remove any impending water. After which the content was reweighed to record the difference in volume, then kept at a room temperature for viscosity test and specific gravity evaluation.

Sodium hydroxide catalyzed trans-esterification

250 ml of waste vegetable oil was transferred to 500 ml beaker and heated to different temperatures of 45°C, 60°C, 70°C and 80°C in a water bath. A solution containing (2.0% to 4.0% (w/v) of sodium hydroxide and 161 ml of 96% ethanol were added individually and vigorously stirred using a magnetic stirrer, and reactions were allowed for 120-340 minutes. Except for temperature, time and catalyst concentration variation, all order conditions such as the concentration of ethanol, and the waste sunflower oil volume remained constant. After which the samples were removed and poured into separating funnel and kept overnight to settle, then the biodiesel in the upper layers was decanted from the glyceride and kept for next step.

Washing and drying

The impure biodiesel obtained were treated with water and acetic acid to remove soap contaminants (ethanol, NaOH, glycerol), then passed through a washing tank for agitation/air bubbled for 60 minutes. Thereafter, the contents were allowed to settle in the settling tank and the wastewater removed and discarded. Since untreated biodiesel contains impurities such as soap, ethanol, fatty acids, sodium hydroxide, glycerides, washing, and drying was done to remove these contaminants which may affect the engine cranks and cause engine knock [9]. Washing was achieved using acetic acid and water that followed repeated agitation to remove grease and other soapy substances from the system.

pH and specific gravity

Washing of impure biodiesel continued until pH near neutrality (7.25) was achieved. And specific gravity was determined using a hydrometer. The amount of biodiesel produced after the trans-esterification processes were calculate using the equation (1) [10] (Figure 1).

Effect of temperature/time/catalyst concentration on biodiesel yield

Three different conditions (Temperature, time and catalyst concentration) were used to evaluate the optimal conditions for biodiesel yield. Temperature estimation was used to evaluate the optimal temperature condition required for waste vegetable oil conversion to biodiesel yield (Table 1). Calculation of Specific gravity and viscosity evaluation were calculated by Oguntal method [10] as shown in equation (2):

$$Yield = \frac{Amount\ of\ biodiesel\ produced}{Amount\ of\ Sunflower\ oil\ used} \times 100 \quad (1)$$

Specific gravity determined is given by Oguntola et al.

$$\text{Specific gravity} = \frac{W_3 - W}{W_4 - W} \quad (2)$$

Where W = weight of specific gravity bottle

W_3 = weight of specific gravity bottle + sample

W_4 = weight of specific gravity bottle + water

Results and Discussion

Purification of sample materials prior to transesterification is a very important indicator for the production of grade 'A' biofuel in the biodiesel producing industry. This is essential in order to overcome the issues of environmental pollution and climate change that culminate contaminated fossil diesel and petroleum hydrocarbon fuels.

During purification, the total number of residues that occupy sample volume in one liter of waste sunflower oil used was 2.4 g (w/w). Thus the quantity of the residue so obtained was large enough to affect the quality of the biodiesel which may invariably cause cracking and engine damage.

In this study, several conditions which included the molecular ratio of the ethanol, heating temperature, Concentration of sodium hydroxide, and time interval were considered as pre-requisite for alkaline catalyzed esterification process. The molar ratio of 10:1 ethanol to waste sunflower oil with NaOH (3% w/v) catalyzed reaction yielded a high amount of biodiesel giving rise to 2:1 glycerol volume to biodiesel produced. The amount of biodiesel produced increased with the increase in temperature at a constant ethanol amount and waste sunflower oil volume (Table 1). Alkaline transesterification in the molar ratio of 10:1 ethanol to oil at the temperature of 70°C yielded a high amount of biodiesel. The volume of biodiesel obtained increased with

Citation: Udeh BA (2017) Biodiesel Production from Waste Vegetable Oil (Sunflower) Obtained from Fried Chicken and Plantain. J Pet Environ Biotechnol 7: 321. doi: 10.4172/2157-7463.1000321

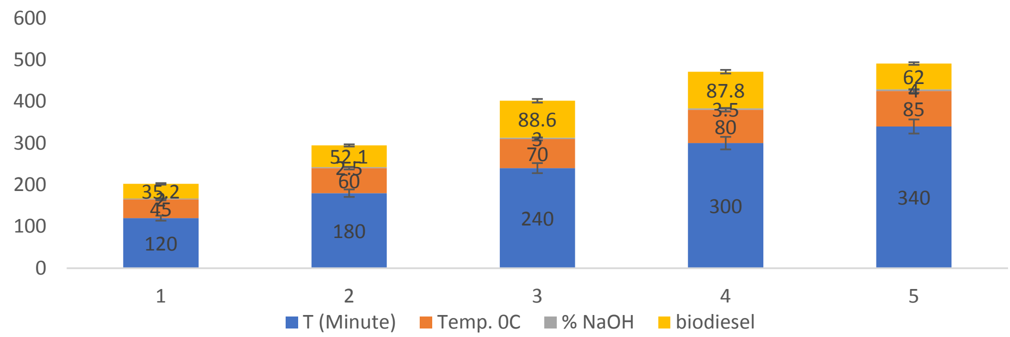


Figure 2: Percentage biodiesel production from waste sunflower oil at optimized conditions.

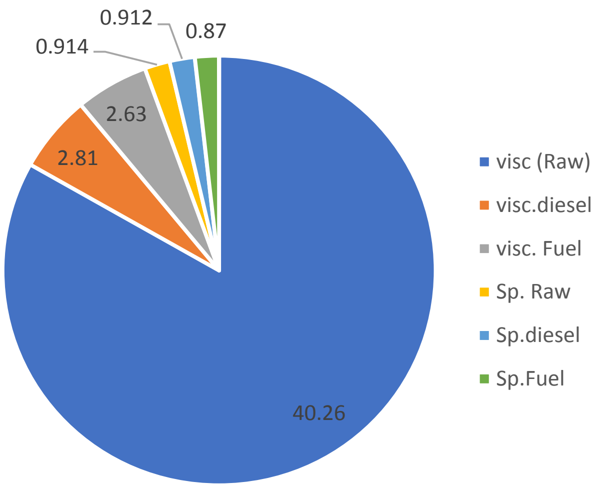


Figure 3: Summarizing viscosity (Visc.) and the specific gravity (sp.) of the raw sunflower oil, biodiesel waste sunflower blend and fuel diesel at room temperature.

Viscosity (cm^{2s-1})	Waste sunflower oil	Biodiesel from waste sunflower oil	Fuel diesel
At room temp.	40.26	2.81	2.634
Specific gravity at room temp. (Kg/m^3)	0.914	0. 912	0.87

Table 2: Comparison of Specific gravity and viscosity of raw waste sunflower oil, produced biodiesel and fuel diesel.

increase in temperature at a constant volume of ethanol with different catalyst concentration until an ambient temperature of 70°C was exceed. Temperature effect on the rate of biodiesel yield was reported by Abba et al. on neem seed biodiesel conversion which increased with increase in temperature. In this study waste, vegetable oil conversion increased with the increase in temperature. At room temperature, the chemical kinetics of the oil requires a higher temperature to increase the fractionation of the waste oil molecules and that is why the increase in temperature greatly influenced the corresponding volume of biodiesel production.

Table 1 clearly shows that temperature can impact biodiesel production [11]. At the temperature of 45°C yield was very low which corresponds to the theory of chemical reaction kinetics, that increase in temperature will lead to the corresponding increase in molecular fractions that characterizes high kinetic rate [10]. At the temperature of 45°C biodiesel yield from waste vegetable oil was very low, the yield increased with increase in temperature. At the temperature of 45°C, 35.2% waste vegetable oil biodiesel was harvested which increased to 52.2% at the temperature of 60°C, the yield continued to increase until after 70°C with a maximum yield of 88.6%. The increase in yield with the increase in temperature could be as the result of the acceleration of the saponification reaction of triglycerides [10]. It was observed that at a higher temperature of 80°C the yield started reducing this could be attributed to the loss of ethanol to evaporation at above 70°C which may have occurred due to temperature effect on conversion rate during transesterification when the optimum temperature for ethanol was exceeded [12]. This indicates that at ambient temperatures the amount of biodiesel yield is high compared to lower/or higher temperatures, the above phenomenon exhibited by waste sunflower oil transesterification process catalyzed by NaOH in this study reveals greater energy efficiency required for low carbon evolution. Olugbenga had a similar report with neem seed oil when treated beyond 65°C methanol escaped as the evaporation point was exceeded which resulted in decreasing the amount of biodiesel produced.

At different concentrations of NaOH and varying temperature conditions, biodiesel yield increased with catalyst concentration until after 3.0% (w/v) NaOH. Yield started decreasing at a concentration above 3.0% NaOH, this could be attributed to alkaline inhibition. Highest biodiesel yield was obtained with 3.0% (w/v) NaOH in 161 ml ethanol at the temperature of 70°C. The yield of 88.6% biodiesel waste vegetable oil blend clearly influenced the rate of reaction during transesterification at the ambient temperature. The high amount of biodiesel yield was dependent on the temperature and increased with increase in temperature until after 70°C the yield started decreasing due to evaporation of ethanol after the boiling point was exceeded (Table 1 and Figure 2). Catalyst concentration evaluation on the amount of biodiesel production with waste sunflower oil and time estimation was used to determine the required time for optimal production. The result obtained from this study shows that percentage yield is dependent on the temperature with respect to time. The temperature of 70°C at 180 minutes yielded 88.6% biodiesel in 3.0% NaOH (w/v) concentration and the yield started decreasing at time interval beyond 180 minutes which shows that the accelerated reaction increased with the temperature. This phenomenon is better explained in Figure 3 in this study.

In the furtherance of this study as is shown in Table 2, the viscosity of waste sunflower oil (40.26 $cm^2 s^{-1}$) is near the conventional plant vegetable oil extract of 40 $cm^2 s^{-1}$ which corresponds to reports on the viscosity of pure vegetable oil by Oguntola et al. in the year 2010. At room temperature waste vegetable oil biodiesel viscosity (2.81 $cm^2 s^{-1}$) was higher than the fossil fuel type (2.634 $cm^2 s^{-1}$) which indicates high octane rating from waste sunflower oil biodiesel blend. This will enhance normal engine runs with minimized particulate matter (smokes) when compared to petroleum hydrocarbon made diesel fuel. Car engines that use high octane rating fuels from reports are more durable and have fewer pollutants than those that are operated with low-grade diesel fuel [13].

The result also indicates that waste sunflower oil made diesel is denser than the petroleum diesel and this will enhance high volatility for a high-speed run in diesel motor engines. Specific gravity is a very important parameter and is usually used in the determination of grade 'A' fuel. The specific gravity of sunflower waste vegetable oil diesel (0.914) against the fossil fuel-based diesel (0.87), indicates that waste vegetable oil diesel blend has higher energy impact when compared to petroleum hydrocarbon based diesel product. The calorific value of waste sunflower oil (40.0 MJ/Kg is within the range from literature report of (40-45MJ/Kg). These high energies dissipated by waste sunflower oil in this study will enhance the capacity of automobiles to cover several miles in a short period of time when compared to conventional fossil fuel blend. The viscosity of sunflower diesel blend was very close to the convectional hydrocarbon-based diesel product which discourages hardware modifications for waste sunflower diesel blend by Deng et al. (Table 2). Interestingly, waste sunflower oil made biodiesel according to this study has a high yield of biodiesel with high energy impact produced in terms of high density expected for clean engine runs and zero particulate matters (Table 2).

Conclusion

In this study, biodiesel was produced using waste sunflower vegetable oil. The higher density value of biodiesel produced by waste vegetable oil material indicates high energy efficiency of waste vegetable oil made diesel product compared to the conventional fossil fuel diesel product. The viscosity of waste vegetable oil diesel blend was higher than the petroleum oil type which refers to high octane value that is useful for normal combustion and cleaner engine with reduced air pollutants such as CO_2, smoke and particulate matters from waste pipe. This will enhance lubrication of the injection engine with the elimination of any material that may affect engine component. From the temperature evaluation, high biodiesel yield was obtained at 70°C with reduced yield at 80°C which indicates ethanol efficiency in waste oil biodiesel yield at 70°C. Since the process yielded 88.6% biodiesel using sunflower waste oil, advocating the application of waste sunflower oil for commercial production is imperative and should be encouraged for de-carbonization of global economy.

References

1. Anya UA, Nwobia NC, Ofoegbu O (2012) Optimized reduction of free fatty acid content on neem seed oil, for biodiesel production. J Basic App Chem 2: 21-28.
2. Fatehi P (2013) Production of biofuels from cellulose of woody biomass.
3. Ramadhas AS, Jayaraj S, Muraleedharan C (2005) Biodiesel production from high FFA rubber seed oil. Fuel 84: 335-340.
4. Aghan D (2005) Progress in energy and combustion. Elsevier 31: 406-487.
5. Patil P, Veera G, Mannarswamy A, Deng S, Cooke P, et al. (2011) Optimization of microwave-assisted transesterification of dry algal biomass using response surface methodology. Bio-resource Technology 102: 1399-1405.
6. Patil PD, Gude VG, Camacho LM, Deng S (2010) Microwave-assisted catalytic transesterification of *Camelina sativa* oil. Energy Fuels 24: 1298-1304.
7. Oguntola JA, Opeoluwa D, Adedoyin AS (2010) Production and testing of coconut oil biodiesel and its blend. Leonardo J Sci p: 95-104.
8. Aworanti OA, Agarry SE, Ajani AO (2013) Statistical optimization of process variables for biodieselproduction from waste cooking oil using heterogeneous base-catalyst. Br Biotechnol J 3: 116-132.
9. Lang X, Dalai AK, Bakhshi NN, Reaney MJ, Hert PB (2001) Preparation and characterization of biodiesels from various bio-oils. Bio-resource Technology 80: 53-62.
10. Abbah EC, Nwandikom GI, Egwuonwu CC, Nwakuba NR (2016) Effect of reaction temperature on the yield of biodiesel from neem seed oil. American Journal of Energy Science 3: 16-20.
11. Olugbenga OA, Layokun SK (2013) Optimization of two-step transesterification production of biodiesel fromNeem (*Azadirachta indica*) Oil. International Journal of Energy and Environmental Engineering (IJEEE) 4: 39.
12. Ragit S (2011) Optimization of neem methylester from transesterification process and fuel characterization as a diesel substitute. Biomass and Bioenergy 35: 1138-1144.
13. Sthyal T, Manivannan A (2013) Biodiesel production from oil using two-step trans-esterification. International Journal of Engineering Research and Application (IJERA) 3: 488-492.