Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.2, No.9, 2012

Passiflora edulis seed oil methyl ester as a potential source of biodiesel

Peter Ngugi Kariuki [1,]*, Paul Ndirangu Kioni [1], George Thuku Thiong'o [2], Samuel Mirie Njenga [1]

1. School of Science, Department of Chemistry, Kimathi University College of Technology, P.O. Box 657-10100, Nyeri, Kenya.

2. Faculty of Science, Department of Chemistry, Jomo Kenyatta University of Agriculture and Technology, P.O. Box 62000-00200, Nairobi, Kenya.

* E-mail of the corresponding author: E-mail: kpeterngugi@gmail.com

This study was supported by Jomo Kenyatta University of Agriculture and Technology (JKUAT) through the Research Production and Extension Department (RPE). Some fuel properties were measured at Kenya Bureau of Standards (KEBS). This publication was made possible by Kimathi University College of Technology (KUCT). All are greatly acknowledged.

Abstract

In recent years, there has been an increasing amount of literature on biodiesel as a feasible source of renewable energy. Compared to fossil energy, biodiesel is environmentally friendlier which makes it a viable option. This study set out with the aim of assessing the use of *Passiflora edulis* seed oil (purple passion fruit) obtained from an industrial fruit juice processing waste. The oil was evaluated as a good potential feedstock for production of biodiesel. In this study *Passiflora edulis* seed oil was transesterified using methanol and potassium hydroxide. A biodiesel yield of 80 % was obtained. The methyl ester had a viscosity of 4.60 mm^2/s, acid value 0.45 mgKOH/g, density 0.89 g/ml, colour 1.60, water content 0.04 %, copper strip corrosion-No tarnish, and flash point > 150 ^{0}C. The fuel parameters measured were within range according to the American Society for Testing and Materials (ASTM) and International Standards Organization (ISO) standards. The current findings add substantially to our understanding of biodiesel and it sources.

Keywords: Transesterification, *Passiflora edulis* seed oil, Methanol, Biodiesel, Methyl ester

1. Introduction

It is becoming increasingly difficult to ignore the fact that fossil fuel reserves continue to diminish and new discoveries are not keeping up with the demand. Consequently, this has encouraged research for other renewable substitutes such as biodiesel which seeks to remedy the above problem. While a variety of definitions of the term biodiesel have been suggested this paper will use the definition first suggested by Pinto *et al.,* (2005) who saw it as the alkyl ester of fatty acids, made by the alcoholysis of oils or fats, from plants or animals, with short chain alcohols such as methanol and ethanol. Other eco-fuels such as hydrogen require extensive engine modifications whereas biodiesel is used directly or as a blend in most diesel engines (Van Gerpen *et al.*, 2004). Other advantages include reduced carbon monoxide, hydrocarbons and particles in exhaust emission (Kiss *et al*., 2005).

Pinto *et al.,* (2005) argue that the direct use of vegetable oils in diesel engines has adverse effects. Firstly, it decreases engine power output and thermal efficiency. Secondly, oil ring sticking and thickening or gelling of the lubricating oil due to contamination by vegetable oils. Thirdly, high viscosity and lower volatility associated with vegetable oils inhibits their direct use in diesel engines as they result to carbon deposits in engines as result of incomplete combustion.

The transesterification process is meant to lower vegetable oil viscosity hence improving the volatility as the molecular weight of triglyceride reduces. The end products of the process are: a mixture of esters of fatty acids, glycerol, alcohol, catalyst and a low percentage of tri-, di and monoglycerides. Most industrial processes employ potassium hydroxide, sodium hydroxide and short chain alcohols (Vicente *et al*., 2004).

The family passifloraceae has over 500 species worldwide of Passiflora of which only about 20 varieties of these fruits are edible and four varieties are cultivated on a large scale, one of them being, *Passiflora edulis* sims var.

edulis which has the most significant commercial value (Nyanzi *et al*., 2005). Two subvarieties of *Passiflora edulis* sims namely the purple passion fruit (*Passiflora edulis* sims var. *edulis*) and the yellow passion fruit (*Passiflora edulis* sims var. *flavicarpa*) grow in Kenya. The fruit is grown for juice extraction and often added to other fruit juices to enhance aroma or for direct consumption of juice or flesh. The seeds are regarded as waste and are usually disposed of after the extraction of juice from the fruit. Studies in Asia and Africa suggest that the yellow, purple and kawanda hybrid (grafted) passion fruit seed are rich in oils with varying contents of unsaturated fatty acids and potential source of biodiesel (Debideen and Sammy, 1978). The seeds have an oil content of 18.5-28.3 % and the content of linoleic acid (C18:2) is between 67.8-74.3 % (Van Gerpen *et al.,* 2004 and Lewis, 2007). Passion fruit is extensively cultivated in Brazil and identified as potential source of biodiesel (Aninidita *et al.,* 2010). The aim of this research was to produce biodiesel from *Passiflora edulis* seed oil obtained from industrial fruit juice processing waste.

2. Materials and Methods

The reagents used were of analytical grade. Methanol was purchased from Sigma (Seelze, Germany). Potassium hydroxide was obtained from Rankem (New Delhi, India). The vegetable oil seed extraction was performed by Soxhlet method from dry *Passiflora edulis* seeds which were an industrial waste from a fruit processing plant in Kenya and the oil yield from the seeds was 25 %. The acid value of the crude oil was first determined by the method described by Van Gerpen *et al*., (2004) before any reaction was performed on it.

2.1 Transesterification Process

Transesterification reaction of *Passiflora edulis* seed oil with KOH was performed at room temperature using a magnetic stirrer (Autoscience AM-5250B, Tianjin Instrument Co.). The amount of KOH and methanol were calculated according to Van Gerpen *et al*., (2004). 88.20 g (100 ml) of *Passiflora edulis* seed oil with a percentage free fatty acid content (% FFA) of 2.41 required 1.25 g of KOH and 24.65 ml of methanol. KOH pellets were dissolved in methanol and added to the vegetable oil. The mixture was stirred on a magnetic stirrer at 700 rpm for 2 hours and left to stand overnight in a separating funnel. The mixture separated into two phases, the lower part being crude glycerin and the upper part the methyl ester layer. The two layers were separated and the methyl ester transferred to a vacuum rotary evaporator set at 65 ^{0}C to remove any excess methanol left.

The biodiesel was washed using a spraying can by placing it in a separating funnel and spraying warm water at 40 ^{0}C representing a quarter amount of the biodiesel being washed. Water was removed at the bottom of the separating funnel on settling. This was repeated until the wash water did not turn pink on addition of phenolphthalein indicator, indicating that the catalyst was washed out. The methyl ester was dried by heating the ester at 60 ^{0}C until the biodiesel changed from cloudy to clear indicating that water had been evaporated. The percentage yield of the methyl ester was calculated. Fuel properties were measured at Kenya Bureau of Standards (KEBS) Nairobi, using ISO and ASTM standards and the results are show in Table 1.

3. Discussion

From the transesterification reaction the yield of biodiesel from *Passiflora edulis* seed oil was 80.37 % by weight of the oil. Comparing the theoretical value of 100 % with 80.37 % yield value, it can be seen that there was some difference. This can be attributed to saponification where the free fatty acids available in the oil form soaps due to reaction with the catalyst hence a lower yield than the theoretical value. This result is further corroborated by the fact that the oil had a high acid value of 4.82 mgKOH/g.

The findings of the current study indicate that the process of transesterification greatly reduces viscosity which in turn leads to improved fuel properties of the *Passiflora edulis* seed oil. Van Gerpen *et al*., (2004) points out that if the viscosity is too high, excessively high pressures can occur in the injection system. Therefore proper viscosity or resistance to flow of diesel fuel is a prime requirement. It is apparent from Table 1 that the kinematic viscosity 4.6 mm^2/s was within ASTM range.

The broad use of the term flash point in biodiesel is sometimes equated with the measure of residual alcohol left in the biodiesel. As can be seen from Table 1, the flash point was greater than 150 ^{0}C implying that it can be used as there is no risk of explosion.

The copper strip corrosion test shows no tarnish on copper. This test monitors the presence of acids in the fuel. For biodiesel, the most likely source of a test failure would be excessive free fatty acids, which are determined from an acid value test. Copper strip corrosion test is a measure of the corrosiveness of the fuel to copper fuel systems.

Water content is an equally vital parameter as the rest. An analysis of water content is a measure of cleanliness of the fuel. For biodiesel, it is particularly important because water can react with the esters, making free fatty acids, and can support microbial growth in storage tanks. Water is usually kept out of the production process by removing it from the feedstocks. However, some water may be formed during the process by the reaction of the potassium hydroxide catalyst with alcohol and also when washing the biodiesel. If free fatty acids are present, water will be formed when they react to either biodiesel or soap. It can be seen from the data in Table 1 that the water content was within range with a value of 0.04. Density (at 15 ^{0}C) 891 kg/m^3 and ASTM colour 1.6 met the given standards.

4. Conclusion

This research has produced biodiesel from *Passiflora edulis* seed oil. The present study was designed to transesterify *Passiflora edulis* seed oil and measure fuel properties. This study has shown that a biodiesel yield of 80 % was obtained. The methyl ester had a viscosity of 4.60 mm^2/s, flash point > 150 ^{0}C and copper strip corrosion-No tarnish. All the fuel parameters measured including: density, ASTM color and water content were within range according to the ASTM and ISO standards. Taken together, these results suggest that the biodiesel obtained from *Passiflora edulis* seed oil can therefore be used as fuel in diesel engines. Besides, the findings from this study make several contributions to the current literature on biodiesel.

References

Aninidita, K., Subrata, K., & Souti, M. (2010). Properties of various plants and animals feedstock for biodiesel production. *Bioresource Technology*, 101, 7201-7210.

Debideen, W., & Sammy, G. M. (1978). Physicochemical characteristics of yellow passion fruit (Passiflora edulis var. Flavicarpa) seed oil. *West Indian Journal of Engineering,* 6, 33-38.

Kiss, A., Dimian, A., Rothenberg, G. (2005). Solid acid catalysts for biodiesel production towards sustainable energy. *Advanced Synthesis & Catalysis,* 348, 75–81.

Lewis, M. (2007). Biofuels mandates cause global warming, scientists say. [Online] Available: http://www.openmarket.org (2012-07-12).

Nyanzi, S. A., Carstensen, B., & Schwack, W. A. (2005). Comparative study of fatty acids profile of *Passiflora edulis* seed oils from Uganda. *Journal of the American Oil Chemists' Society,* 82(1), 41-44.

Pinto, A. C., Guarieiro, L., Rezende, M. J., Ribeiro, N. M., Ednildo, A., Torres, E. A., Lopes, A. W., Pereira, A. W., & Andrade, J. B. (2005). Biodiesel: An Overview. *Journal of Brazilian Chemical Society*, 16(6B), 1313-1330.

Vicente, G., Martinez, M., & Aracil, J. (2004). Intergrated biodiesel production: A comparison of different homogenous catalysts systems. *Bioresource Technology*, 92, 297-305.

Van Gerpen, J., Shanks, B., Pruszko, R., Clements, D., & Knothe, G. (2004). Subcontractor Report. August 2002–January 2004. *Biodiesel Production Technology*. National Renewable Energy Laboratory: USA, Colorado; pp 1-52.

Table 1. Fuel properties of *Passiflora edulis* methyl ester

PROPERTY	METHOD	APPARATUS	LIMITS	CSEK
Kinematic viscosity at 40 ^{0}C (mm^2/s)	ISO 3104	Automatic viscometer (HMV 472 HERZOG)	3.5 - 5.0	4.6
ASTM colour	ASTMD 1500	Tintometer (Lovibond PFX 880)	Max 3.5	1.6
Copper strip corrosion (3 h at 50 ^{0}C rating, Max)	ISO 2160	Air oven, (Memmert)	Class 1	No tarnish
Density @ 15 ^{0}C (kg/m^3)	ISO 12185	Density meter (DMA 4500)	860 - 900	891
Flash point ^{0}C, min	ASTMD 93	Pensky Martens closed cup tester	130 Min	> 150
Water content % v/v	ASTMD 95	Dean and Stark apparatus	0.05	0.04