Study Of The Physicochemical Analysis Of Biodiesel Produced From Waste Vegetable Oil.

C. O. Okpanachi, J. C. Chukwu, E. N. Yisa, H. Z. Abdullahi, S. Sadiq

Abstract: The study of the physicochemical analysis of biodiesel produced from waste vegetable oil in Sedi, Minna, Nigeria was carried out in order to ascertain the quality of the biodiesel produced as regards physical and chemical parameters which include visual appearance, colour, cloud point, flash point, and cetane index, diesel index, kinematic velocity, calorific value. Biodiesel is a renewable resource that can replace petroleum diesel which comes from fossil fuels that are limited and will be exhausted in the near future. Biodiesel can be made from the transesterification of vegetable oils, animal fat, greases and oil crops such as soybean and it is biodegradable. The biodiesel produced was subjected to physicochemical analysis and results of cetane index was established to be 52, the flash point using pensky martens close cup was determine to be 160^{0}C, diesel index using IP21, 0.3411, kinematic viscosity at 40^{0}C to be 4.12 and calorific value of 10867cal/g. The investigated physicochemical parameters show that the biodiesel produced is suitable for use in diesel engines without modifications and is cheaper to produce compared to petroleum diesel.

Keywords: Waste, Vegetable oil, Methanol, Transesterification, Biodiesel, Physicochemical, Analysis, Biodegradable.

1. INTRODUCTION

Biodiesel is an organic, non-toxic and biodegradable fuel which can be made from renewable resources like vegetable oil, animal fat and plants [1]. It is mostly made by chemically reacting lipids like vegetable oil or animal fat with an alcohol thereby producing fatty acid esters [2]. The reaction requires a catalyst, usually a strong base, such as sodium or potassium hydroxide [3]. Biodiesel can be used in pure form (B100) or may be blended with petroleum diesel at any concentration in most injection pump diesel engines. A system known as the 'B' factor is used to state the amount of biodiesel in any fuel mix [4]. Biodiesel as an alternative fuel, has many advantages such as environmental friendly, renewable, non-toxic, the process is cost effective since excess methanol can be recovered and re used while the other raw material, waste vegetable oil, is readily available and affordable [5]. Vegetable oil, like biodiesel, belongs to the same category of compounds known as esters, and biodiesel is commonly produced by the tranesterification of the waste vegetable oil or animal fat feed stock [2]. The reaction needs the waste vegetable oil and methanol to react in a reactor to form biodiesel in the presence of potassium hydroxide (KOH) as catalyst [6]. The catalyst is needed because the methanol is slightly soluble in the oil phase, hence the catalyst assist in solubility to allow the chemical reaction to progress at a reasonable rate. This reaction occurs at low temperature and pressure and produces a crude biodiesel and glycerin [7]. At the end of the reaction, the glycerin, which is heavier, is drawn off the bottom of the vessel and the biodiesel is further purified to remove residual catalysts and then dried. The biodiesel and glycerin are then pumped to storage tanks [8].

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To help in finding solution to the energy problem in Nigeria, especially in powering diesel engine buses for public transportation, diesel engines for generation of electricity for homes and industrial use by the use of biodiesel, and most importantly to reduce greenhouse gas (GHG) effect by reducing the use of petroleum diesel [9], this study was carried out, also to put to further use the waste vegetable oil from eatries and homes which can contaminate the public water system and the ecosystem as a result of improper disposal. Thus, the physicochemical analysis of the biodiesel produced in Sedi Minna was carried out to evaluate the chemistry of the diesel produced and ascertain its suitability for use in diesel engines either directly or blended with petroleum diesel.

2. MATERIALS AND METHODS

Waste vegetable oil was collected from three eatries in Minna and blended to create a homogenous mix. A sieve of 300 mesh was used to filter the oil and remove unwanted particles, then 500ml of the oil was heated to a temperature of about 100^{0}C and stirred to evaporate moisture which can affect the reaction [10]. 100ml of methanol was poured into the reactor followed by the catalyst, potassium hydroxide (KOH), then filtered and dried waste vegetable oil and transesterification takes place at this stage. The mixture was stirred to agitate the reagents and the reaction was completed within 25 minutes [11], and the products were moved immediately to the separation vessel. The glycerol then settled to the bottom of the container after esterification because glycerol is heavier than the biodiesel produced. The settling started immediately and the mixture was left for about 12 hours to make sure that all the glycerol has settled out. The left over methanol was removed from the biodiesel by heating the biodiesel to a temperature of 65^{0}C at which methanol will evaporate from the biodiesel [12]. The methanol vapour was cooled and condensed into a liquid state for storage. The crude biodiesel produced was then washed to remove the potassium hydroxide (KOH) catalyst and traces of glycerol. Before water was used to wash the biodiesel, acid was added to the biodiesel to neutralise any residual catalyst and to split any soap that may have formed during the reaction as soap will react with acid to form water soluble salt and free fatty acids [13]. Water being denser than the biodiesel settled at the bottom of the container, Water washing is used to remove any remaining catalyst, soap, salts, methanol or free glycerol from the biodiesel [14]. The washed biodiesel was heated to a temperature of 100^{0}C to vapourise any water still present in the biodiesel. The American Society for Testing and Materials (ASTM) procedures; ASTM D1500, ASTM D1298, ASTM D2500, ASTM D97, ASTM D445, ASTM D93, ASTM D664, ASTM D86, ASTM D613, ASTM D240 were used for the analysis to obtain the colour, specific gravity at 15^{0}C, cloud point, pour point, kinematic viscosity, flash point, total acid number, distillation at 90%, recovery, cetane index, cetane number, calorific value [3], [15]. The PH of the biodiesel was determined by using a PH meter, the water content % volume was performed by distillation and the diesel index was obtained using the IP21 test method.

3. RESULTS AND DISCUSSION

A representative sample of the biodiesel produced was analysed. The physicochemical analysis of the sample was done and parameter such as visual appearance was obtained. The biodiesel was further analysed using American Society for Testing and Materials (ASTM) procedure for the physicochemical analysis.

Table 1: *Results of the physicochemical analysis of the biodiesel produced using waste vegetable oil.*

S/N	PARAMETER/UNIT	TEST METHOD	RESULT
1	Appearance	Visual	Clear, yellowish liquid
2	Colour	ASTM D1500	1.5
3	Specific gravity @15^{0}C	ASTM D1298	0.8544
4	PH	PH Meter	7.19
5	Cloud point ^{0}C	ASTM D2500	9
6	Pour point ^{0}C	ASTM D97	5
7	Kinematic viscosity @40^{0}C	ASTM D445	4.12
8	Flash point (Pensky Martens close cup), ^{0}C	ASTM D93	160
9	Water content % volume	Distillation	ND
10	Sediment %		< 1
11	Total Acid no(TAN), mgKOH/g	ASTM D664	1.04
12	Distillation at 90 % recovery, ^{0}C	ASTM D86	338
13	Cetane index	ASTM D86	52
14	Cetane no	ASTM D613	10.25
15	Diesel index	IP21	0.3411
16	Calorific value, cal/g	ASTM D240	10867

ND – Not Detected

The results in Table 1 showed that the colour gives a value of 1.5; specific gravity at 15^{0}C indicated a value of 0.8544 which means the biodiesel produced is a high energy content fuel with a high power and mileage output. The PH value is 7.19 making it slightly basic and the cetane index is 52 which reveal a good rating for the biodiesel. The flash point gives a value of 160^{0}C making it less inflammable and safer compared to petroleum diesel that have a flash point of 52^{0}C minimum. The cloud point which is the temperature at which the crystals of solid biodiesel become visible is at 9^{0}C and the pour point which is the temperature at which the biodiesel becomes solid and can no longer be pumped is 5^{0}C and these does not constitute any challenge in Nigeria as the country is found in the tropics, where the climate is seasonally damp, very humid with warm temperatures throughout the year [16]. The kinematic viscosity at 40^{0}C is 4.12 and the calorific value of the biodiesel was established to be 10867cal/g (ASTM D240) which represents the amount of heat transferred to the chamber during combustion and the available energy in the fuel.

4. CONCLUSION

At the end of this study focused on the physicochemical analysis of biodiesel produced from waste vegetable oil in Sedi Minna, parameters analysed conform to standards. Biodiesel which is a fuel derived from the esterification of fats and oils has similar properties to that of diesel produced from petroleum diesel and can be used directly to run existing diesel engines or as a mixture with petroleum diesel. Biodiesel is biodegradable and can be used without modifying or changing the existing engines and produces less gas emissions such as sulfur oxide. The process of producing biodiesel is cost effective since excess methanol can be recovered and recycled and waste vegetable oil is readily available and affordable. The by-product, glycerol, is economically valuable and can be used in cream production, soaps, lube, and nitroglycerin which is further used to make dynamite. The production of biodiesel can go a long way in meeting energy needs and aid in bringing down cost of production and transportation.

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