SEET'16
Engineering for Self-Reliance

Proceedings of the 2016 Annual Conference of the School of University of Technology, Akure, Nigeria, 16-18 August, 2016 Engineering & Engineering Technology (SEET), The Federal

PRODUCTION AND CHARACTERIZATION OF BIODIESEL FROM *MORINGA OLEIFERA LAM* SEED OIL

Aliyu M.[1], Adebayo S. E.[1], Animashaun I. M.[1], Mohammed I. S.[1] and Busari M.B.[2]

[1]*Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Nigeria;*

[2]*Centre for Genetic Engineering and Biotechnology, Global Institute of Bioexploration Unit, Federal University of Technology Minna Nigeria*

(muhammad.aliyu11@yahoo.com)

ABSTRACT

Moringa oleifera plant is an important plant of great economic value as its parts are being used for various purposes. As such, the plant is gaining great acceptance from the public as an alternative source of fuel, this study is therefore aimed at production and characterization of biodiesel from seed oil of the plant.Oil was extracted from Moringa oleifera Lam seed and converted to biodiesel through transesterification and then purified. Some physical characteristics of the biodiesel produced were determined and compared with petroleum diesel fuel. The following properties of the produced biodiesel were observed; specific gravity (0.870), viscosity (2.98 mm^2/s), flash point (171 ^0C), boiling point (120 ^0C), free fatty acid (0.42 mgKOH/g), acid value (0.84 mgKOH/g) and refractive index (1.38914 at 25.70 ^0C). The corresponding values of these properties for petroleum diesel are; specific gravity (0.848), viscosity (2.96mm^2/s), refractive index (1.664). It was concluded that moringa oleifera Lam seed is a viable source for biodiesel production.

Keywords; Biodiesel, Extraction, *Moringaoleifera*, Transesterification,

INTRODUCTION

Petroleum-based fuel plays an important role in the energy sector mainly as fuel for powering plants, running vehicles and motor engines. However, this fuel is not sustainable and the price is also not stable. Due to these factors, new alternative energy especially renewable energy has been widely studied to fulfil the world's insatiable demand for energy. Nevertheless, most of these alternative energies are only capable of generating thermal and electrical energy, whereas more than 40% of the world energy demand is in liquid form **(**Demirel, 2012**)**. Therefore, the use of biomass as a new source of alternative liquid fuel has attracted a lot of attention in recent times.

Biodiesel is defined as a domestic and renewable fuel derived from vegetable oil, which meets the specification of American Society for Testing and Materials (ASTM) D6751 for diesel engines (Fukuda *et al.*, 2001). Biodiesel consists of alkyl esters, which are produced from the trans-esterification reaction between triglycerides and alcohol. It is a form of diesel fuel manufactured from vegetable oils, animal fats, or recycled restaurant greases. It is safe, biodegradable, and produces less air pollutants unlike petroleum-based diesel **(**Abdulkareem**,** 2011**)**. Biodiesel can be used in its pure form (B100) or blended with petroleum diesel (Jayashri *et al.*, 2013).

Moringa oleifera is a tropical multipurpose tree that naturally grows in India, South-Saharan Africa and South-America. The oil from *moringa oleifera* seed is a good source of betacarotene, Vitamin C, protein, iron and potassium. It is not very popular as a source of food in Nigeria; it is consumed mostly among the Hausas. It is used industrially in the production of cosmetics and lubrication. It is domestically used for cooking. Its leaves, flowers, seeds, roots and bark can be used as food and has medicinal and therapeutic functions, especially in developing countries. *Moringa oleifera* seed oil is also used for biodiesel production (Abdulkareem**,** 2011).

Crude vegetable oils and fats are being extracted with a number of methods such as; hydraulic pressing method, supercritical fluid method, mechanical method and solvent extraction method. The most widely used methods for the extraction of oil from *Moringa oleifera* are mechanical method and solvent extraction method (Orhevba, 2013).

Solvent extraction is though a complex operation, it constitutes the most efficient method for the recovery of oil from any oil bearing material and yields high quality oil. It is interesting to note that while solvent extraction gives higher yield and less turbid oil, the operating cost is relatively low (Maria *et al*., 2008). Solvents commonly used for extraction include hexane, benzene and methylene chloride.Previous researchers have extracted *Moringa oleifera* oil using solvent and aqueous enzymatic extraction methods (Abdulkareem, 2005) but focused on the study of the physicochemical properties of the oil obtained.This research is therefore aimed at production and characterization of biodiesel from *Moringa Oleifera* seed oil.

MATERIALS AND METHODS

Preparation of Seeds

Indigenous Moringa *Oleifera* seeds were collected within Minna town in Niger State of Nigeria. The damaged seeds were discarded and the seeds in good condition were cleaned, dehulled, dried and the hulls were later separated by winnowing. The whitish seeds were ground prior to oil extraction using soxhlet apparatus and n- hexane as solvent. All reagents used were of analytical grade.

Oil Extraction

The extraction was carried out as described by Garcia-Favos*et al* (2010). A quantity of *Moringa oleifera* crushed seeds (1.00 mm in size) were placed in a thimble and fed to a labscale Soxhlet extractor fitted with a 1-L round-bottom flask and a condenser. The extraction was executed for 6 hours with 350 ml of the solvent. The mass of the seeds was noted. The extracted oil yield was expressed as percentage, which is defined as weight of oil extracted over weight of the sample taken. The product was filtered and oven-dried to a temperature of 90ºC - 100ºC to remove the remaining solvent content in the oil sample (Aliyu et al., 2013).

Biodiesel Production from *Moringa* Oil

100 ml of *moringa* oil was measured and poured into a 150 ml conical flask and heated at 4550^{0}C using a water bath. A solution of sodium methoxide was prepared in a 250ml beaker using 0.50 g of NaOH pellet and 21 ml of methanol. The solution was properly stirred until the NaOH pellet is completely dissolved. The NaOH methoxide solution was then poured into the warmed *moringa* oil and stirred vigorously for 30 minutes using a magnetic stirrer, and the mixture was left to settle for 24 hours in a separating funnel.After settling, the upper layer which was the biodiesel was decanted into a separate beaker while the lower layer which comprises of glycerol and soap was collected from the bottom of the funnel. The raw biodiesel was washed with distilled water to remove some traces of soap and other contaminants. The quantity of biodiesel collected was measured and recorded.

Flash Point Determination

The flash point was determined using pensky-marten equipment. The apparatus consists of a small cup into which the sample was put; the cup was gradually heated while being stirred to distribute heat uniformly in the cup and the temperature of the oil was monitored with a thermometer. At regular interval, the cup was exposed to naked flame. The temperature at which the biodiesel catches fire was determined; this temperature is the flash point of the sample.

Viscosity Determination

The fenske viscometer was used to determine the viscosity of the sample. The sample was put in the viscometer so that it just coincided with the level of the upper mark on the viscometer. The fall of the tube to the lower mark was monitored using a stop watch and the viscosity was calculated.

Refractive index determination

Refractive meter was used to determine the refractive index of the biodiesel produced. Few drops of the sample were placed on the glass slide of the refractor meter. Water at 350^{0}C was circulated around the glass slide to keep its temperature uniform. Therefractor meter was viewed through the eye piece; the dark portion viewed was adjusted to be in intersection with the cross. At no parallax error, the pointer of the scale pointed on the refractive index. The value was noted and recorded.

Specific gravity determination

An empty beaker was weighed, and then a specific volume of distilled water was added to the beaker and weighed again. The beaker was emptied and dried so that an equal quantity of oil could be poured into the beaker and weighed also. The specific gravity is calculated as shown in equation 1.

$$\textbf{specific gravity} = \frac{\text{weight of oil sample}}{\textit{weight of equal volume of water}} \quad (1)$$

Determination of boiling point

Sample of the diesel was transferred into a boiling point tube and the tube later placed on the boiling point apparatus. Heat was then supplied to apparatus and the boiling point of the sample was read immediately boiling commenced.

Determination of acid value

The mixture of ethanol and toluene in the ratio 1:1 by volume was neutralized prior to use with potassium hydroxide solution in the presence of 0.3 ml of indicator per 100 ml of mixture. 2 g of sample was weighed into 250 ml conical flask, 50 ml of previously neutralized mixture of toluene and ethanol was added to the flask. A few drops of phenolphthalein indicator were added and the content titrated against 0.1 ml/litre solution of ethanolic potassium hydroxide solution until the indicator changes to pink colour. Two determinations were carried out for the sample. The acid value was determined using equation 2.

$$\textbf{Acid value} = \frac{V \times C \times 56.1}{m} \quad (2)$$

Where,

V is ethanolic potassium hydroxide solution

C is exact concentration of ethanolic potassium hydroxide solution used m

is Mass of the test sample

56.1 is molar mass expressed in grams per mole of potassium hydroxide.

RESULTS AND DISCUSSION

The results obtained from the determination of physicochemical properties as presented in Table 1 showed that the biodiesel produced had specific gravity of 0.870 kg/l, which is within the ASTM standard value (0.86-1.0 kg/l). This value explained why the oil floats on water as it is denser. This result agrees with the values reported by Hawash (2010) who obtained the specific gravity of a blend of biodiesel with *Moringa oleifera* oil to be 0.89kg/l.

Table 1: Physicochemical Properties of biodiesel produced from *Moringa oleifera* seed oil and the conventional diesel

Parameters	Biodiesel	Petroleum-based Diesel	ASTM D6751

Specific gravity (kg/l)	0.870	0.848 2.96	0.86- 1.00
Kinematic viscosity (mm^2/s)	2.98	1.664	6.0 max
Refractive index	1.38 at 25.7^{0}C	84.0	1.245- 1.675
Flash point (^{o}C)	171	250-350	90.00-130.00
Boiling point (^{o}C)	120	0.6 mg KOH/g	-
Free Fatty Acid (FFA)	0.42 mg KOH/g	1.2 mg KOH/g	3.00-5.00 max
Value Acid	0.84 mg KOH/g		0.80-1.00

The viscosity of the biodiesel of 2.98 mm^2/s is within the limit of the ASTM standard and very low compared to 33.5 mm^2/s reported by (Aliyu, 2013) and 5.60 mm^2/s obtained by Uzama *et al.* (2011). This value is consistent with the values reported by (Sharma *et al.*, 2008). This indicates that the oil is a good feedstock for biodiesel production. High viscosity, about 11-17 times higher than diesel fuel, affects the flow properties of the fuel, such as spray atomization, consequent vaporization, and air-fuel mixing in the combustion chamber, leading to an adverse effect on the combustion process (Nakpong and Wootthikanokkhan, 2010). The lower the viscosity the better, as it will aid easy pumping of fuel in an engine. A higher viscosity leads to poorer atomization of the fuel injectors. This will nevertheless help to reduce barrel leakage. The synthesized biodiesel had a flash point of 171^{o}C, which is higher than the conventional diesel (84 ^{0}C). It is also higher than the value of 89.20 ^{0}C obtained by Uzama *et al.* (2011). This is an advantage over petroleum diesel as it ensures safety during storage handling and transportation.

The synthesized biodiesel had a boiling point of 120 ^{0}C, free fatty acid of 0.42mgKOH/g and an acid value of 0.84mgKOH/g which compares well with conventional biodiesel with boiling point of 250 – 350 ^{0}C, free fatty acid of 0.6 mgKOH/g and acid value of 1.2 mgKOH/g. Acid value of a fuel sample shows its acidic nature when in contact with some materials in an engine. The result also agrees with the values reported by Uzama *et al.* (2011). Variation in values may be as a result of operating conditions used during the extraction process.

The biodiesel has a refractive index of 1.664 at 26 ^{0}C which is close to the standard and between the results of Ojojo *et al.* (2011) and Nakpong and Wootthikanokkhan (2010) which indicates a good result.

CONCLUSION

Based on this research, the high oil yield and the parameters obtained from the characterization of the biodiesel shows that *Moringa oleifera* oil seed is actually a viable feedstock for biodiesel production. This was also clearly attested to by its excellent physicochemical properties and its superior fattyacid composition when compared with some edible vegetable oil.

REFERENCES

Abdulkareem S.M., Long K., Lai O.M., Muhammad S.K.S., Ghazali H.M. (2005). Some physicochemical properties of *Moringa oleifera* seed oil extracted using solvent and aqueous enzymatic methods. *Food Chemistry* 93, 253–263.

Abdulkareem, A.S. Uthman, H. Afolabi A. S. and Awenebe O. L. (2011). Extraction and Optimization of Oil From Moringa Oleifera Seed as an Alternative Feedstock for the

Production of Biodiesel, Sustainable Growth and Applications in Renewable Energy Sources, Available from: http://www.intechopen. com/ books/sus tainable-growthand-applications-in-renewable-energy-sources/extraction-and-optimization-of-oilfrom-moringa-oleifera-seed-as-an-lternative-feedstock-for-the-pr

Aliyu, A. O., Nwaedozie1 J. M. and Adams A. (2013). Quality Parameters of Biodiesel Produced from Locally Sourced *Moringa oleifera* and *Citrulluscolocynthis L*. Seeds Found in Kaduna, Nigeria *International Research Journal of Pure & Applied Chemistry 3(4): 377-390*

Demirel, Y. (2012): Energy, Green Energy and Technology, Springer-Verlag London Limited Available online at*: www.springer.com/cda/content/.../cda.../ 9781447123712-c2.pdf*

Fukuda, H., Kondo, A., and Noda H. (2001). Biodiesel fuel production by transesterification of oils. *Journal of Bioscience and Bioengineering*; 92:405–16.

Hawash, G.E Diwani, and S.E Rafei, (2010). Kinetics and Thermodynamics of Oil Extraction from Jatropha Curcas in Aqueous Acidic Hexane Solutions, *6(11):293-300*

Jayashri N, Nair, J. Deepthi K. and Siva kalyani (2013): Study Of Biodiesel Blends and Emission Characteristics of Biodiesel, International Journal of Innovative Research in Science, Engineering and Technology 2(8)

Maria, Y.L., Natan, F.A., Widiyanti, P., Ikasari, D., Indraswati, N. and Soetaredjo, F.E. (2008). Extraction of Neem oil (*Azadirachtaindica A. Juss)* using n-hexane and ethanol: studies of oil quality, kinetic and thermodynamic. *Journal of Engineering and Applied Sciences*, 3 (3), 49-54.

Nakpong, P. and Wootthikanokkhan, S. (2010), Optimization of biodiesel production from *Jatrophacurcas* L. oil via alkali-catalyzed methanolysis, *Journal of Sustainable Energy & Environment 1, 105-109.*

Ojojo, S.M., Ogunsina, B.S., Adelaja, A. and Ogbonnaya, I. A. (2011). Study of an Effective Technique for the Production of Biodiesel from Jatropha Oil.

Orhevba B. A, Sunmonu M.O., and Iwunze H. I. (2013). Research and Reviews: Journal of Food and Dairy Technology Extraction and Characterization of Moringa oleifera Seed Oil 1 (1)

Sharma, Y. C., Singh, B. and Upadhyay, S. N. (2008), Advancements in development and characterization of biodiesel: A review. *Fuel*; 87: 2355–2373

Uzama, D., Thomas, S.A., Orishadipe, A.T., and Clement, O.A. (2011). The Development of a blend of *Moringa oleifera* oil with Diesel for Diesel Engines. *Journal of Emerging Trends in Engineering and Applied Sciences*, 2(6): 999-1001