



**Biodiesel Production from *Moringa Oleifera* Seed Oil using MgO/Al<sub>2</sub>O<sub>3</sub> Catalyst**

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**Abstract**

*Increase in world fuel consumption, rising in fuel price, depletion of fossil fuels and global warming problems lead to the search for renewable alternative sources of energy. Moringa oleifera seed oil had been identified as one of the non-edible biodiesel feedstock but it problem is high free fatty acid content, in an attempt to search for suitable catalyst which produce low acid content biodiesel, the suitability of using MgO/Al<sub>2</sub>O<sub>3</sub> as a catalyst in the transesterification of moringa oleifera seed oil into biodiesel was investigated. The transesterification was done using methanol and 5wt. % MgO/Al<sub>2</sub>O<sub>3</sub>, at 60°C using response surface method. The moringa oleifera methyl ester (MOME) produced had an acid number of 0.2 mgKOH/g, carbon residue of 0.02 wt. %, cetane number of 48.2, cloud point of -13°C and density of 0.87 g/cm<sup>3</sup>. It had a flash point of 140°C, higher heating value of 41.58 MJ/Kg, pour point of -10°C and a viscosity of 4.6 mm<sup>2</sup>/s. All the properties of the MOME were within the acceptable ASTM limits which indicates that MgO/Al<sub>2</sub>O<sub>3</sub> is a suitable heterogeneous catalyst for the production of MOME.*

**Keywords:** Biodiesel; Production; Heterogeneous catalyst; Activity; Transesterification.

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**1.0 INTRODUCTION**

Fossil fuels are the major world energy used (Lee *et al.*, 2014; Mofijur *et al.*, 2014; Muciño *et al.*, 2014). However in recent years, the world is confronted with both fossil fuel depletion and environmental degradation problems (El\_Kassaby and Nemit\_allah, 2013) and energy demand is projected to increase due to increase in population and urbanization (Atabani *et al.*, 2013). The negative effect of fossil fuels on environment and human health coupled with its depletion (Jividallesaadi and Raeissis, 2013; Gandure *et al.*, 2014), this directed research towards the production of fuels from alternative renewable feedstock capable of fulfilling increases in energy demand (Wei *et al.*, 2014), in order to reduce dependence on petroleum and meet the requirements of the global environment, the development of eco-

friendly alternative fuels become necessary (Widayat and Agam 2013). Biodiesel produced from renewable feedstock is considered as one of the potential alternative to conventional diesel due to carbon neutrality (Guo *et al.*, 2013) and it can be used in diesel engine without modification (Sunthitikawinsakul and Sangatith, 2012). Biodiesel which is accepted as an attractive alternative fuel which is prepared by transesterification of vegetable oils and animal fats with an alcohol in the presence of a catalyst. (Canakci, 2007).

Feedstocks used for the production of biodiesel varies from one region to another depends on climate and its availability; generally, the most abundant vegetable oil in particular region is the most common feedstock (Rashid *et al.*, 2008). However, biodiesel production from conventional

sources (first generation feedstocks) may place strain on food production, price and availability (Mukhtar *et al.*, 2012). Therefore, the search for additional regional biodiesel feed stocks is important. The Moringaceae is a single genus family of moringa oleifera oil seed tree with 10 known species. These, moringa oleifera which ranges in height from 5 to 10m, is the most widely known and utilized (Morton, 1991)

Moringa oleifera is cultivated in northern and south-west of Nigeria (Rabiu, 2005). It is locally called zogale, Ewe ile and igbale in hausa, youroba and igbo languages (Chris, 2012). It is fast growing tree, drought tolerant and it can growth any region with 25-300cm<sup>3</sup> rain fall range (Anwar *et al.*, 2007). It seeds contain about 33-41% w/w oil (Rabiu, 2005).

*Moringa oleifera* seed oil contained high free fatty acid (Rashid *et al.*, 2008), homogenous alkali catalyst transesterification is not suitable for biodiesel feedstock contained high free fatty acid because free fatty acid react with alkali to form soap which may reduce biodiesel yields (Knothe, *et al.*, 2005; Kulkarni, *et al.*, 2006; Lin, *et al.*, 2009) therefore it preferable to use base heterogeneous catalyst than homogeneous catalyst in biodiesel production from high content free fatty acid feedstock due to its advantages which include easier separation and purification of biodiesel (Arzamendi *et al.*, 2007; Kansedo *et al.*, 2009; Zabeti, *et al.*, 2009). The aims of this research are to investigate the possibility of using MgO/Al<sub>2</sub>O<sub>3</sub> catalyst to convert *moringa oleifera* seed oil to biodiesel with low acid value.

## 2.0 MATERIALS AND METHODS

### 2.1 Materials:

Moringa oleifera seeds were obtained from Bagudo New Market, Bagudo Local Government, Kebbi State, Nigeria. The Moringa oleifera seed were dehulled with sharp metal knife, shed dried and grinded into powdered form using pestles and mortar.

### 2.2 Methods

The oil was extracted using soxhlet extraction method and its acid value determined, Transesterification reaction of *Moringa oleifera* seed oil with methanol was carried out in a three-neck round bottom flask equipped with a magnetic stirrer, a thermometer and a reflux condenser. 5 wt. % of MgO/Al<sub>2</sub>O<sub>3</sub> were added into 75cm<sup>3</sup> of methanol and the mixture heated at 42°C for about 5 minute in a 250 cm<sup>3</sup> beaker. The solution was added to 100g of *Moringa oleifera* seed oil in the 500cm<sup>3</sup> three-neck round bottom flask. The mixture of the catalyst, methanol and *Moringa oleifera* seed oil were placed on top of heating mantle at 60°C for about 2 hours with constant stirring of the solution. After completion of transesterification, the reaction mixtures were allowed to cool and settled for 24 hours in a separating funnel. After 24 hours the mixture formed three layers; crude biodiesel, glycerin and catalyst phases. This phase separation was seen within few minutes. However, the crude biodiesel was cloudy and opaque. The clear separation was observed after 24 hours of settling. The MOME was further purified using the centrifugation method. The physico-chemical properties of the MOME were determined. The properties determined were acid value, carbon residue, cetane number, cloud and pour points. Others determined were density, flash point, heating value and viscosity. These properties were determined according to the ASTM standard.

### 3.0 RESULTS AND DISCUSSION

#### 3.1 Results

Table 1: Physico-chemical properties of the MOME.

Properties		ASTM Limit
Acid value	0.20mgKOH/g	0.5 max
Carbon residue	0.02 wt. %	0.3 max
Cetane number	48.2	47min
Cloud point	-13 °C	-
Density	0.87 g/cm <sup>3</sup>	0.90 max
Flash point	140 °C	130 min
High heating value	41.58MJ/Kg	-
Pour point	-10 °C	-
Kinematic Viscosity	4.6 mm <sup>2</sup> /s @40°C	3.5-5.0max

#### 3.2 Discussion:

The acid content of the oil is the percentage of free fatty acid composition present in the oil (Almustapha *et al.*, 2009). It also refers to the number of KOH required to neutralize 1g of oil and it is measure used to estimate the storage quality of the oil (AOCS, 1976). The acid content of the MOME was 0.20 which is below the maximum acceptable value (0.5max) given by ASTM D6751. The values obtained is slightly lower than the value  $0.38 \pm 0.03$  for *Moringa oleifera* biodiesel using KOH catalyst as reported by Umer *et al.*(2011), and lower than 2.2 for MOME using sulphated tin oxide enhanced with SiO<sub>2</sub> (SO<sub>4</sub><sup>2-</sup>/SnO<sub>2</sub>-SiO<sub>2</sub>) super acid solid catalyst reported by Gerald *et al.*(2010), which indicate that MgO/Al<sub>2</sub>O<sub>3</sub> catalyst significantly reduced the acid content and is more efficient than KOH and SO<sub>4</sub><sup>2-</sup>/SnO<sub>2</sub>-SiO<sub>2</sub> catalyst. The result obtained showed that the MOME may not cause negative effect on internal combustion engines if used as fuel since the higher acid content leads to severe corrosion in fuel supply system of combustion ignition engine (Atabani *et al.*, 2012)

Carbon residue is a fuel measure the amount of residual carbon left after evaporation and pyrolysis of biodiesel, which results in its relative propensity to produce coke (Phan *et al.*, 2008). This can cause blockage of engines nozzles and corrosion which may lead to engines damage by cracking. The carbon residue was found to be 0.020 wt. % which is lower than the ASTM

recommended maximum range (0.05 max) reported by Atadashi *et al.*(2011), an indication that the produce biodiesel may produce low carbon dioxide emissions during combustion (Phan *et al.*, 2008).

High viscosity is the major problem preventing the use of vegetable oils and animal fats directly in diesel engines as presented above the kinematic viscosity of *Moringa oleifera* used in this research work was found to be 44.10mm<sup>2</sup>/s. (Arjun *et al.*, 2008). Higher viscosity has significant impact on the operation of engine fuel injectors and atomization and may lead to fuel injector, piston sticking, gum formation and engine wear (Knothe *et al.*, 2008; Haldar *et al.*, 2009). The viscosity of the MOME was 4.67mm<sup>2</sup>/s measured at 40°C and was within the ASTM and EN14214 recommended range of 1.9–6.0 max and 3.5–5 max respectively as reported by Atadashi *et al.* (2011) and slightly lower than 4.83 mm<sup>2</sup>/s reported by Umer *et al.*(2008) . The results obtained indicate that transesterification of *moringa oleifera* using MgO/Al<sub>2</sub>O<sub>3</sub> substantially reduce the kinematic viscosity when compare the kinematic viscosity of crude *moringa oleifera* with that of produced MOME and biodiesel produced may not causes problems to the fuel injector and engine.

Density is an important property for automobile fuel injection systems (Giwa *et al.*, 2014) because it influences the amount of fuel injected in the engine cylinder hence it affect the compression ignition engine performance and it influenced the air-fuel

ratio and energy content of fuel (Saxena *et al.*, 2013) The density of the MOME was  $0.87 \text{ g/cm}^3$  which is within the ASTM recommended limit of 0.90 max and indicate that MOME may enhance air-fuel ration hence it will gives higher energy content.

Flash point of a fuel is the temperature at which it will ignite when exposed to a flame or a spark. Flash point of vegetable oil methyl esters are usually lower than those of vegetable oils due to its low viscosity and density (Saxena *et al.*, 2013) Flash point ( $140^\circ\text{C}$ ) of the MOME was found to be much higher than the minimum standard value of  $130^\circ\text{C}$  recommended by ASTM, which indicates that the MOME has meets the minimum requirement for storage and handling safety (Atabani *et al.*, 2012). The flash point of MOME  $\text{MgO}/\text{Al}_2\text{O}_3$  catalyst decreases the degree of saturation of *Moringa oleifera* seed oil fatty acid during transesterification making it more volatile than biodiesel produced from *Moringa oleifera* seed oil using  $\text{SO}_4^{2-}/\text{SnO}_2\text{-SiO}_2$  and KOH catalysts reported by Gerald *et al.* (2010) and Kafuku and Mbarawa. (2010) respectively. This indicates produced MOME can be safely stored and handled below  $140^\circ\text{C}$  temperature.

Cloud and pour point these are the important parameters which determine the suitability of using biodiesel fuel in the arctic region. Biodiesel cloud point is the temperature at which biowax form cloudy in biodiesel (Saxena *et al.*, 2013; Gauray and Sharma, 2014) while pour point is the lowest temperature at which the fuel remains fluid. Low cloud and pour points leads to blockages in pipes and filters of vehicle fuel system due to the formation of saturated fatty acid methyl esters solid crystal as result of solidification (Nazmiye and Hakan, 2014). Biodiesel has higher cloud and pour point than conventional diesel (Saxena *et al.*, 2013). Gauray and Sharma (2014) reported that pour point is always lower than the cloud point; this is in contrast with the finding of

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this study, which showed that pour and cloud points of MOME are  $-10$  and  $-13^\circ\text{C}$  respectively. But similar pour point  $-10^\circ\text{C}$  for corn oil methyl ester was reported by Nazmiye and Hakan (2014). The results indicate that MOME is suitable for use in a region where the seasonal temperature is above  $-10^\circ\text{C}$ .

High heating value is the amount of heat released by combustion of one gram of fuel at its initial temperature and pressure (Fassinou *et al.*, 2011). It is one of the important fuel parameters that determine the quality of biodiesel (Demirbas, 2008). It is a measure of the energy content of fuels and it determines its possible energy output (Sanli *et al.*, 2014). It also determine the amount of fuel consumed and its thermal efficiency (Rao *et al.*, 2010). The high heating value of the MOME was  $41.58 \text{ MJ/Kg}$  which indicate that the MOME may produce higher energy output for better engine performance.

Cetane number is the common indicator use to assess the quality of diesel fuel related to its ignition time and combustion quality (Oliveira and Da Silva, 2013). A higher Cetane number reduces formation of white smoke and indicated good ignition property and good control of the combustion hence increased engine efficiency (Meher *et al.*, 2006; Marti'nez *et al.*, 2014). The cetane number of the MOME was 48.2 which is within the ASTM recommended limit of 47min. The result showed that the MOME will ignited faster and may produce low exhaust emissions (Leung *et al.*, 2010; Sokoto *et al.*, 2011)

## 4.0 CONCLUSION

The results presented in this study has shown the possibility of producing low acid content biodiesel from *Moringa oleifera* seed oil using  $\text{MgO}/\text{Al}_2\text{O}_3$  as catalyst because all the determined physicochemical properties of the MOME met the ASTM biodiesel standards, Hence  $\text{MgO}/\text{Al}_2\text{O}_3$  is a suitable catalyst for the production of biodiesel from *Moringa oleifera* seed oil.

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