SEM STUDY OF CORROSION EFFECT OF BIODIESEL ON FUEL INJECTOR SYSTEM

BY

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DEDICATION

I dedicate this project to the Almighty God, for seeing me through my final year project, and also to my mother Mrs. Alebiosu Beatrice, my brothers and my sisters and my fiancé Shittu Pamilerin for their support, love and encouragement.

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CERTIFICATION

I hereby certify that ALEBIOSU TOLUWALOPE MARTINS with Matric number MEE/12/0854 carried out this project under my supervision, in the department of Mechanical Engineering, Federal University, Oye-Ekiti, Nigeria in partial fulfillment of the requirement for award of Bachelor of Engineering degree (B.Eng) in Mechanical Engineering.

ENGR. O.M SANUSI ______________ 08/11/17

(PROJECT SUPERVISOR) **SIGN AND DATE**

DR. ENGR. A.A. ADELEKE ______________ 20/02/2018

(HEAD OF MECHANICAL ENGINEERING DEPARTMENT)SIGN & DATE

______________ ______________ 9/11/17

EXTERNAL SUPERVISOR SIGN & DATE

ACKNOWLEDGMENT

Firstly my gratitude goes to God almighty for his protection, his provision, his kindness and everything he has done in my life and my academics. I say thank you Daddy. I would like to thank Dr. Oyelaran for giving me the opportunity to work on this project whose suggestions and assistance have been valuable for this project. I also express my special thanks to my supervisor Engr. Sanusi for the daily discussion, assistance and kind suggestions in this work.

I would also thank my fiancé for her prayer, support and motivation. Finally I would like to thank my parents for their love and prayers.

ABSTRACT

Biodiesel is a renewable alternative fuel to the fossil diesel and is getting more popularity because of depletion of fossil fuels and their lower environmentally pollution. This paper presents an investigation with scanning electron microscopy SEM analysis into the corrosive behavior of Black date (Atili) biodiesel on the injector of the fuel system of a diesel engine. The experimental study was based on the methods of weight loss and scanning electron microscopy. Test specimens prepared from the injector of a diesel engine were exposed to different blends of Black date (Atili) biodiesel for a period of 28 days under ambient conditions. Corrosion rates were determined accordingly. After the three samples were analyzed by Scanning Electron microscopy (SEM) and the image of the areas contain most deposited were capture. The result of corrosion shown that blends with biodiesel concentrate of 10% exhibited not much effect as loss in weight was negligible within the immerse period while blends above 10% concentration has higher corrosion rate.

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND

The economic growth of any country depends on the availability of the energy sources such as coal, petroleum and natural gas. The world is presently facing two major problems namely fossil fuel depletion and environmental degradation. Hence, it is necessary to find suitable renewable alternative fuel for better energy security and environmental protection. Among the available renewable alternative fuels, biodiesel is considered as a better substitute for the fossil diesel ((Kapilan, 2014)).

According to(Nuhu, 2014) Nigeria covered about 923,768.00 sq. kilometers and lies between latitude 40 and 140 north of the equator and longitudes 30 and 140 east of the Greenwich meridian. This is entirely within the tropical zone. Although Nigeria is wholly within the tropics, its climate varies from the tropical at the coast to sub-tropical further inland. There are two marked seasons: the rainy season, lasting from April to October and the dry season, from November to March. Absolute maximum temperature in the coastal areas of the south is 37°C while the absolute minimum temperature is 10°C. Black date (Atili) plant grows well in the tropics; its non-edible seeds are attracting attention as a major source of oil for biodiesel. The oil yielding plant is a multipurpose and drought resistant shrub; the geographical position of Nigeria suggests the potential opportunities in terms of seeds production.

In the last few decades, there have been growing concerns over vegetable oils as source of material in preference to petroleum or mineral oil. The main factor for this concern is due to environmental issues that regard mineral oil as major contributor of volatile organic compounds (VOCs) which themselves are responsible for most of our present recalcitrant pollution problems threatening the ecology. Oil processing expands the use of crops and also brings value to waste products. Vegetable oils derived from plant seeds have been playing vital roles to provide comfort in human lives in various aspects. Plant seeds have been used since antiquity as sources of vegetable oil. Examples of some plant seeds which have been conventionally exploited commercially for this purpose includes soya beans, cotton seed, groundnut, corn, palm seeds and sunflower (Mohammed M. Aji, 2015). He also further that Fruits and Seeds of plants are a good source of food for humans, including animals, because they contain nutrients necessary for plant's initial growth, including many healthy fats, such as omega fats. In fact, the majority of foods consumed by human beings are seed-based foods. Edible seeds include cereals, Legumes and nuts. Oilseeds are often pressed to produce rich oils – sunflower, flaxseed, rapeseed, sesame. Seeds are typically high in unsaturated fats and, in moderation, are considered a healthy food, although not all seeds are edible. Fats and oil are generally grouped as edible and inedible. They usually consist of mixtures of the glycosides' of various fatty acids.

Black date "Atili" also known as "Canariumschweinfurthiibursaraceae" is found in the kingdom plantae, because it is made up of multicellular and non-motile organism and its leaves also contain chlorophyll. It possesses vascular bundles placing it in the sub-kingdom tracheophyta. It falls under the super division spermatophyte seed plants because it is a higher gymnosperm. The embryo bears two cotyledons which places it in the class magnoliopsiodaedicotyledons. It also belongs to the sub-class rosidae because of its polypetalous corolla. In Nigeria, the fruit of the perennial tree plant is called "ubeokpoko" in Igbo and "Atili" in Hausa. The fruit is commonly found in large quantities in Pankshin area, Plateau state of Nigeria and is also produced in similar quantities in other state of northern and south-eastern Nigeria, The fruit yields fats and oil.

The availability of energy resource plays a critical role in the progress of a nation. Almost all the human energy needs are currently met from the fast depleting fossil fuels associated with serious environmental consequences. Over the last century, there has been more than 20 fold increase in the consumption of energy worldwide and all major sources excepting hydropower and nuclear electricity are the finite sources and therefore are likely to be exhausted in near future(Gaurav Dwivedi 1, 2013).

According to(Ihwan Haryono, 2014).The use of biodiesel fuel in automobile is to save fuel consumption from petroleum and improve air quality. Biofuels, fuels derived from biomass have been gaining the attention as of highly renewable, biodegradable and locally available. Biomass liquid fuels are Bio alcohols; ethanol is the most common, Biodiesel; obtained from vegetable oil or animal fats and Bio crude; synthetic oil. Biofuels are carbon-neutral, nontoxic and reduce emission of volatile organic compounds. These fuels are not only green in nature but also help to reduce dependence on imported oil.

1.2 Objective and scope

The objective of this research work was to study the SEM analysis of corrosion effect of Black date (Atili) biodiesel on the fuel injection components such as nozzle.

CHAPTER TWO

2.0 LITERATURE REVIEW

Biodiesel as transport fuel Biodiesel is a renewable diesel fuel that can be made from any natural oil or fat. The term "biodiesel" generally refers to "fatty acid methyl ester" (FAME) made by Trans esterification - a chemical process that reacts a feedstock oil or fat with alcohol (usually methanol) and a base (mostly, potassium hydroxide) catalyst. In technical terms, biodiesel is a diesel engine fuel comprised of monoalkyl esters of long chain fatty acids derived from vegetable oil or animal fat designated as B100. So far, many vegetable oils have been used to produce biodiesel such as sunflower, soya bean, peanut, cotton seed, linseed, palm coconut; and non-edible oils like mahua, neem, karanja and Jatroph.

(ULLAH, 2013)Reported that Crude vegetable oil is mostly (about 95%) composed of triglyceride and some free acids like monoglycerides and triglyceride. Triglyceride contains long chain-acids generally called fatty acids; the structure is given in **Figure 1.** These long chains are unbranched, containing 16 to 18 carbons which have similar properties to petro diesel like cetane number, a dimensionless number which indicate fuel ignition quality. These long chains of hydrocarbon in similar properties make a substitute of diesel fuel.

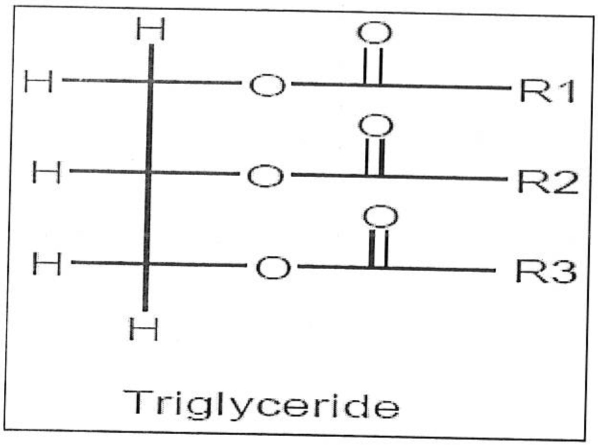


Figure 1 Triglyceride (kali mullah 2013).

There are mainly five types of carbon chain of each fatty acid moiety in the oil derived from soybean or animals fats. It is designated by two numbers; the first number shows the number of carbon while the second number shows the number of double bonds. These fatty acid chains are given below in more detail.

Palmitic: R= (CH_2)14-CH_3. It is designated as (16:0). The number of carbons is 16 (including the one where R is attached to) and no double bonds.

Stearic: R= (CH_2)16-CH_3. It is also fully saturated; the numbers of carbons is 18 and designated as (18:0).

Oleic: R= (CH_2)7=CH $(CH_2)7CH_3$. It is unsaturated; the number of carbons is 18 with 1 double bond, and designated as (18:1).

Linoleic: R= $(CH_2)7CH$=CH-CH_2-CH=CH $(CH_2)4CH_3$. The number of carbons is 18 with two double bonds and designated as (18:2).

Linolenic: R= $(CH_2)7CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH_3$. It is highly unsaturated with 18 carbons having three double bonds, designated as (18:3).

Vegetable oil can be used directly in diesel engine, but it needs high modification in engine. The problem is caused by high viscosity of vegetable oil. The high viscosity restricts the flow of oil through the fuel line, causes problem in fuel injection and form some deposits(Abdul Monyem, 2000). To avoid the operational problems and to make possible their use like diesel, the oil needs to be modified to low viscosity. Four methods are generally used to decrease its viscosity, these are: to make their blend with petro diesel, micro emulsification, hydrogenation, pyrolysis, and trans-esterification. The most common method used is the trans-esterification, which produce alkyl ester (having low viscosity) from vegetable oil.

As the vegetable oil is a mixture of different form of fatty acids, each fatty acid has different physical and chemical properties because of different number of carbon and double bond. So if the mixture contains high amount palmitic acid or methyl palmitate will have different melting point than the mixture concentrated in methyl linoleate. The chemical formula and melting point of each fatty acids and their corresponding ester are shown in **Table 1.**

Table 1 Characteristics of common fatty acids and their methyl ester *(ULLAH, 2013)*

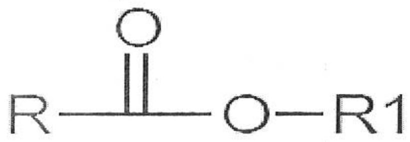
Fatty acid Methyl ester	Common acronym	Formula	Melting point [^{0}C]
Palmitic acid Methyl palmitate	C 16:0 C17:0	$C_{16}H_{32}O_2$ $C_{17}H_{34}O_2$	63-64 30.5
Stearic acid Methyl stearate	C 18:0 C19:0	$C_{18}H_{36}O_2$ $C_{19}H_{38}O_2$	70 39
Oleic acid Methyl oleate	C18:1 C19:1	$C_{18}H_{34}O_2$ $C_{19}H_{36}O_2$	16 -20
Linoleic acid Methyl linoleate	C18:2 C19:2	$C_{18}H_{32}O_2$ $C_{19}H_{34}O_2$	-5 -35
Linolenic acid Methyl linolenate	C18:3 C19:3	$C_{18}H_{30}O_2$ $C_{19}H_{32}O_2$	-11 -52/-57

2.1 Corrosion behavior of metal and alloys in biodiesel

Currently, the level of corrosion in biodiesel fuel is specified by the 'copper strip corrosion test' and determined by ASTM specifications according to (B. Singha, 2010). A polished copper strip is immersed in a specified volume of biodiesel for a specific time and temperature. The copper strip is then removed and washed. The color of the strip is then assessed as per the ASTM standard. However, the 'copper strip corrosion test' provides limited information with respect to corrosiveness as it measures the level of corrosion that will occur when copper is present as metal. The level of corrosion also depends on the type of alloy in contact with biodiesel fuel. In general, copper alloys have been found to be more corrosive than the ferrous alloys. Apart from biodiesel, corrosion also occurs in engines operating on ethanol.

2.2 BASICS OF BIODIESEL

Biodiesel is a substitute of fossil fuel for diesel engine and defined as: a fuel comprised of mono-alkyl ester of long chain fatty acids derived from vegetable oils or animal fats and also known as "mono-alkyl ester" is the product of the reaction of alcohol, such as methanol or ethanol with oil or fats (triglyceride) by trans esterification reaction(ULLAH, 2013). It is designated as B100 and the chemical structure is given below.



R is methyl or ethyl from methanol and ethanol respectively, used in the reactant. R1 is a long chain of fatty acids having 16 to 18 carbons. The long branched hydrocarbon chain of fatty acid methyl ester similar to long-chain of petro-diesel makes it an alternative diesel fuel.

Kapilan, (2014) also Reported that biodiesel was produced from the Jatropha oil and studies were carried-out to study its effect on the engine components. If the acid value of the vegetable oil is high, then a two-step trans esterification is one of the ways of producing biodiesel from it. The biodiesel produced from vegetable oil should satisfy the ASTM / EN Standards. He also reported that the engine performance with the biodiesel is similar to the diesel. The properties of the biodiesel produced from different vegetable oils are shown in the **Table 2.**

Table 2. Properties of the biodiesel produced from different oils.***Kapilan, (2014)***

Property	Honge Biodiesel [11]	Sunflower Biodiesel [12]	Cotton seed oil Biodiesel [13]
Kinematic viscosity (mm^2/s) (40 °C)	4.33	4.439	6.0
Acid Value (mg KOH/g-oil)	0.23	--	--
Density (kg/m^3)	--	--	850
Flash point (°C)	174	183	--
Cold filter plugging point (°C)	--	-3	--
Cloud point (°C)	--	3.4	-2

2.3 Fuel Properties of Biodiesel

Biodiesel as stated earlier is mono-alkyl ester made from natural and renewable vegetable oil and animal fats based feedstock. The biodiesel is similar in fuel characteristics to conventional diesel as shown in **table 2.**

According to(Gaurav Dwivedi, 2013). He also compares the fuel characteristics specified by standard specification of different countries. The data indicates that the biodiesel is compatible with petroleum diesel and can be blended in any proportion with diesel to create suitable biodiesel blend. The blending of biodiesel with diesel is expressed as Bxx where xx indicates the percentage of biodiesel in the blend For example B20 blend is made by mixing 20% biodiesel with 80% diesel which can be used in CI engine with no modification with comparable power output, When higher blends including B100 is used the higher Brake Specific Fuel Consumption (BSFC). Countries like Germany, Italy, France, USA, India etc have developed their own biodiesel specification and are almost comparable. The flash point and acid value of DIN standard are slightly higher than ASTM standard and are normally followed all during the work.

Table3: Comparison of fuel properties of Different Standards (GauravDwivedi, 2013).

S.No.	Fuel Properties	Austria (ONC-1191)	India (BIS-15607)	France (EU-15412)	Germany (DIN-EN-590)	Italy (UNI-10946)	USA (ASTM-424720)
1.	Density at 15^0C (g/cm^3)	0.85-.89	0.87-0.89	0.87-0.89	0.875-0.89	0.86-0.90	0.88
2.	Viscosity at 40^0C (mm^2/s)	3.5-5	1.9-6	3.5-5	3.5-5	3.5-5	1.96
3.	Flash point ^{0}C	100	130	100	110	100	130
4.	Cold Filter Plugging Point ^{0}C	0-5	0-5	N.A	0-10/-20	N.A	N.A
5.	Pour point ^{0}C	N.A	N.A	10	N.A	1-5	15-18
6.	Cetane number	≥49	≥40	≥49	≥49	N.A	≥47
7.	Neutralization number (mgKOH/g)	≤0.8	≤0.5	≤0.5	≤0.5	≤0.5	≤0.8
8.	Carbon residue (%)	≤0.05	≤0.05	N.A	≤0.05	N.A	≤0.05

The properties of biodiesel especially its viscosity and ignition properties are similar to the properties of fossil diesel **Table 4**. Biodiesel has several advantages, lubricating effects of biodiesel is important in avoiding wear to the engine, the alcohol components of biodiesel contain oxygen which helps to complete combustion of the fuel. Biodiesel is sensitive to cold weather and may require special anti –freezing precautions for temperate countries similar to those taken with standard diesel.

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Table 4: Properties of Biodiesel in Comparison to Fossil Diesel (Rufai et al 2014).

Properties	Fuel	
	Diesel	Biodiesel
Density (kg/s)	0.84	0.88
Viscosity (mm^2/s)	5	7
Flash Point (°C)	80	120
Calorific Value(MJ/kg)	42.7	37.1
Cetane Number	50	56
Fuel Equivalence	1	0.91

Table 5. shows that the biodiesel is highly oxygenated fuel which result in better combustion performance and flame temperature compared to diesel and lesser emit lower gaseous emissions. Higher biodiesel flash point makes it storage less risky than diesel. All these properties indicate that the biodiesel is a suitable substitute of diesel. The following are the general feature of the engine and fuel performance.

Table 5: Compare the fuel Properties of Biodiesel with Diesel *(Gaurav Dwivedi 1, 2013)*.

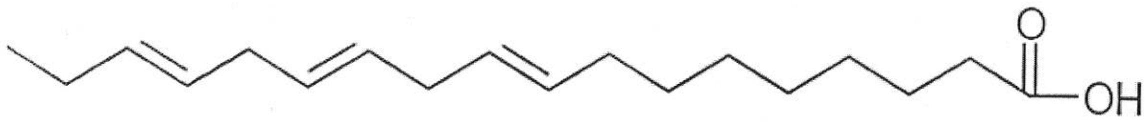
S.No.	Fuel properties	Diesel	Biodiesel
1	Fuel standard	ASTM D 975	ASTM D 6751
2	Fuel composition	C_{10-21} HC	C_{12-22} FAME
3	Lower heating value(MJ/kg)	42.52	37.12
4	Kinematic viscosity at 40^0C	1.3-4.1	1.9-6.0
5	Density at 15^0C(kg/m3)	848	878
6	Water, by wt.(ppm)	161	0.05% max.
7	Carbon, (wt %)	87	77
8	Hydrogen, (wt %)	13	12
9	Oxygen, (wt %)	0	11
10	Sulphur, (wt %)	0.05 max.	0
11	Boiling point,(^0C)	188 to 343	182 to 338
12	Flash point,(^0C)	60 to 80	100 to 170
13	Cloud point,(^0C)	-15 to 5	-3 to 12
14	Pour point,(^0C)	-35 to -15	-15 to 16
15	Cetane number	40 to 55	48 to 60
16	Auto ignition temperature, (^0C)	316	N.A
17	Stoichiometric air/ fuel ratio, (w/w)	15	13.8

2.4 Technical Problems Associated With the Use of Biodiesel as Engine Fuel

Engine fuel system is designed to store the fuel and deliver it to the combustion chamber with an appropriate fuel rate and at required velocity, taking into consideration the pressure, viscosity and air fuel mixture ratio (Nuhu, 2014). The compression ignition technique of robust diesel engine is fuel economic and emits low pollutants such as CO2, CO, H. The inventor ran his diesel engine on peanut oil at the Paris exposition in 1900. Its smooth operation on vegetable oil established that diesel engines can run on variety of vegetable oils. However, many engine problems may be experienced while using raw vegetable oil as fuel, like coking of injectors; excessive engine carbon deposits on piston head and excessive engine wear. To compensate this shortcoming, most researchers have recommended using Trans esterification of vegetable oils as a means of reducing viscosity

2.5 ABOUT BIODIESEL OXIDATION

Vegetable oil (Triglyceride) is a mixture of different fatty acids which are explained earlier in detail. The trans-esterification reaction does not change the fatty acid profile, so the fatty acid moiety connected to mono alkyl ester (Biodiesel) are same as in parent oil. The fatty acid chains are highly unsaturated which makes it prone to oxidation; multiple double bonds present in the chain like in linoleic or linoleic acid are more susceptible towards oxidation. The chemical nature of the fuel is changed with oxidation which produces hydroperoxides, which in turn produce short fatty acids chain and aldehydes. The acid value is increased due to oxidation as of highly acid formation which causes corrosion of metals. The hydroperoxides can also polymerize to produce gums and sediments which plug the fuel filter and make deposits on fuel system, and also very destructive to elastomers. The olefin unsaturated fatty acid present in alkyl ester occurs in methylene-interrupted configuration. The structure given in **Figure 2.**Is for linoleic acid, having three double bonds (ULLAH, 2013).



methylene - interrupted

Figure 2. Show the structure of fatty acid

2.6 EFFECT OF BIODIESEL ON ENGINE COMPONENTS

According to (Kapilan, 2014). The engine fuel injection components such as fuel filter, gasket and fuel lining tube were taken out from the beakers containing biodiesel (B100), B5 and diesel. These components were observed for the corrosion and sediment deposition. The size of the fuel filter was enlarged during the storage period as compared to the B5 and diesel. A thin layer of deposition was observed at the metal holder of the fuel filter which was kept in the Jatropha Biodiesel (B100) sample. This is due to the auto oxidation, hygroscopic nature, polarity, higher unsaturated components and solvency properties of the Jatropha biodiesel. It also causes degradation elastomers. The metal holder exposed to B5 and diesel does not have any deposition. He continues to enlighten that B5 use will not affect the fuel components which are used in the diesel engine components. If Jatropha Biodiesel (B100) is used as fuel in the diesel engine, then it will affect the fuel injection components which may leads to clogging of the injection pumps and filters, poor engine performance and early replacement of few fuel injection components.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Materials

The test specimens were steel coupons prepared from the **nozzle** of a diesel engine with Model No. : **DL 30S 1184, Part No 201 - 12063, and used in the Lister engine.**

The specimens were surface grinded on emery paper to 600 grit finish. For the purpose of removing scratch and oxide layer on the specimens, they were then polished with1.0 μm diamond paste, washed with distilled water and rinsed with methyl alcohol. The samples were then dried, weighed in analytical chemical balance and stored in desiccators ready for exposure. The test media for the experiment included: Blends of Black date (Atili) biodiesel with fossil diesel (B30, B20 and B10).

3.2 Black date (Atili) Biodiesel

Black date (Atili) biodiesel oil was collected from Plateau State North-Central Nigeria, "Atili" (Canariumschweinfurthii) is the fruit of the perennial tree plant also called "atili"' tree. In Nigeria, the fruit is called 'ubeokpoko' in Ibo and "atili" in Hausa. The fruit is commonly found in large quantity in Pankshin, Plateau State of Nigeria and is also produced in similar quantities in other states of the northern and south-eastern Nigeria.

The biodiesel was extracted by purchasingthe fresh and well ripe fruits of the black date (Atili) from local market. The fruits were sorted out to remove any dirt or foreign material present in them. They were then washed in cold water to remove any dirt adhering to the surface of the fruits.

The separation of the pulp with the seed was done manually. After the separation, the pulp is pounded into smaller particles and then dried. The grounded pulp was packed into the extraction chamber of the sox let extractor; while a solvent (NHexane) was poured into the round bottom flask of the extractor. The whole set-up was mounted on a heating mantle at 65℃and allowed to reflux for about 8 hours. The extract was filtered (to remove impurities) and evaporated using a rotary evaporator to isolate the free flow lipid from the solvent. The extracted oil was further evaporated in an oven at 150°C to eliminate any moisture and residue solvent that may be present. The weight of the oil produced and the residue were measured to ascertain the percentage of the oil content.

Table 6 physical Characteristics of the Oil ***(Mohammed M. Aji, 2015)***

Parameters	Analyzed
Color	Dark green
Viscosity at 29 (°C)	36

Flash point (°C)	111
Density (g/cm³)	0.87
Specific gravity	0.87

3.3 Biodiesel blends

Biodiesel blend is a mix of biodiesel in petro diesel; it is represented by "B" followed by a number which shows the percentage of biodiesel in the fuel. Different blends i.e. B0 to B100 can be made, the main purpose of this work is to investigate some of the problems. B10 means 10% of biodiesel in the fuel, it can be made by mixing 10ml of biodiesel in 90 ml of petro diesel to make 1 liter of blend. Three blends (B10, B20, and B30) are used in this project work.

3.4 Experimentation

Weighed test pieces of specimens were separately and fully immersed in the following test media: B30, B20 and B10 respectively and allowed to stand for 28 days accordance to (Nuhu, 2014)**figure 3**; The weight loss was determined by finding the difference between the initial weight of the coupon and the final weight after exposure for that period. The corresponding corrosion rates in millimeter per year (mmpy) were calculated.

Figure 3 show immersed period in different blends.

$$The\ corrosion\ rate\ (mmpy) = \frac{KW}{\rho AT}$$

Where: *K* is constant = 8,760 hrs/yr,

W is weight loss (g),

ρ is Density of specimen (g/cm^3),

A is Area of specimen (cm^2),

T =Time of exposure (hours).

Calculation

K = 8,760 hrs/yr

W = B10=0.0001, B20 = 0.0004, B30 = 0.0009.

A = 1.5mm

p= 0.87

T = 672hrs

$$Corrosion\ rate\ mmpy = \frac{KW}{pAT}$$

$$for\ B10 = \frac{8760 * 0.0001}{0.87 * 1.5 * 672} = 0.001$$

$$for\ B20 = \frac{8760 * 0.0004}{0.87 * 1.5 * 672} = 0.004$$

$$for\ B30 = \frac{8760 * 0.0009}{0.87 * 1.5 * 672} = 0.009$$

3.6 Scanning Electron Microscopy (SEM)

The microscopic study is required for envision the coupons surface to see any cracks or fractures on the surface. The light microscope can provide plenty of information about the surface damage or formation of some sort of materials on the surface. It works on the principal of illuminating the polymer sample with light using glass lenses, the images are then viewed with computer at different magnifications. The coupons analyzed with the SEM (scanning electron microscope) then used for more profound study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1RESULTS

4.1.1 Corrosion rates: The result of corrosion rates of different blends of biodiesel on test specimen within the immersion period is presented in **Figure 4.**

4.1.2 Scanning electron microscopy: The samples were subjected to SEM analysis .The SEM micro structure of the samples are presented in **figure** 5-7 with their corrosion effect. The test specimens were immersed in different blends of biodiesel.

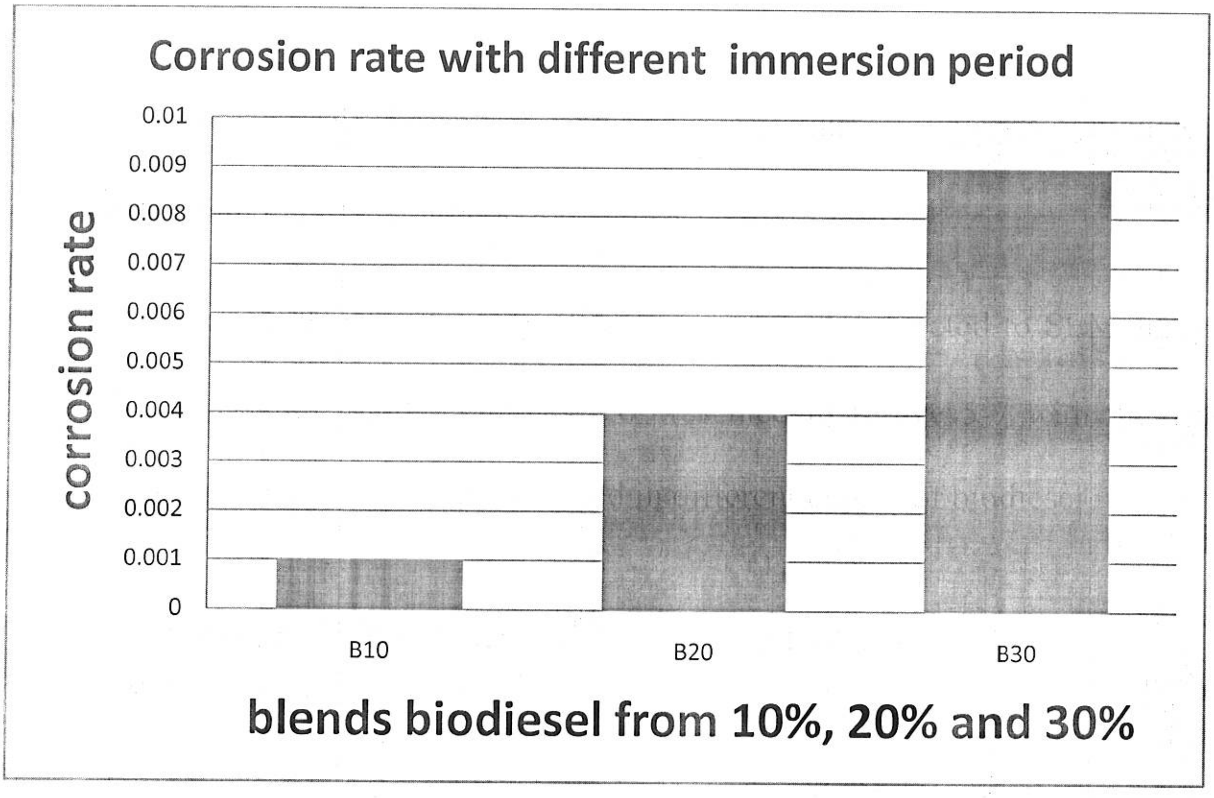


Figure 4shows the corrosion rate of different blend biodiesel of Black date (Atili).

Finally, the three samples were analyzed by Scanning Electron Microscopy (SEM) and images of the areas containing most deposits were captured.

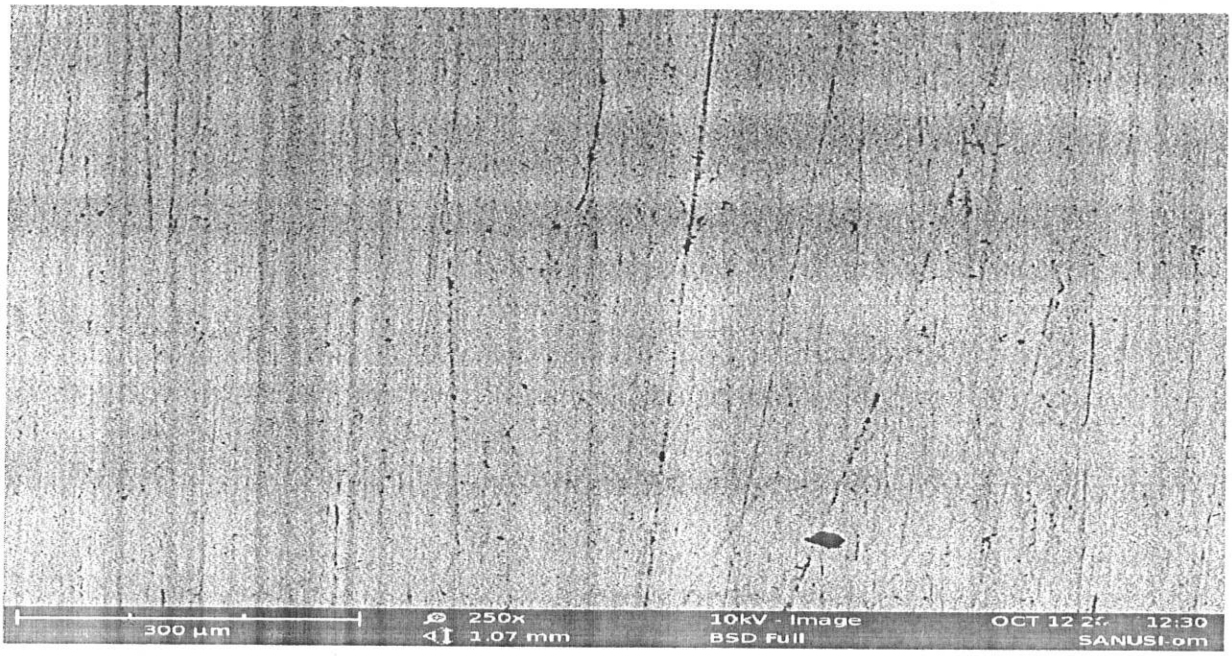


Figure 5 show the 10% of blend biodiesel of Black date (Atili)

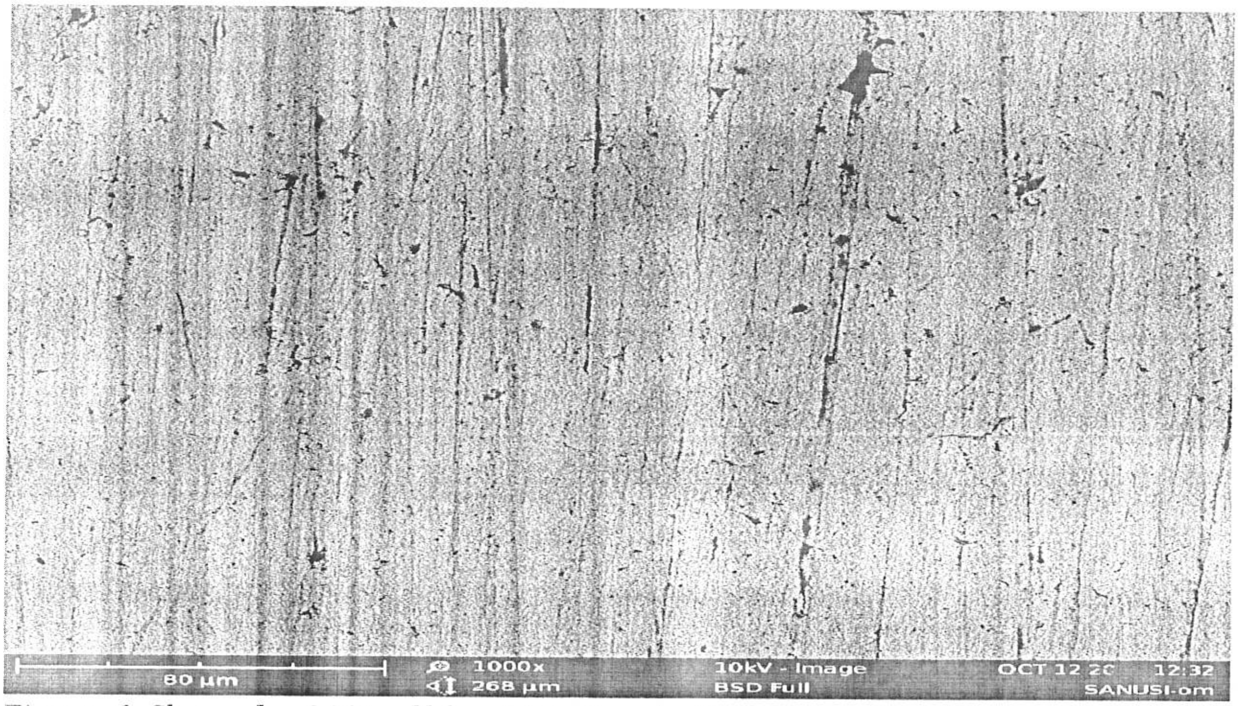


Figure 6. Show the 20% of blend biodiesel of Black date (Atili).

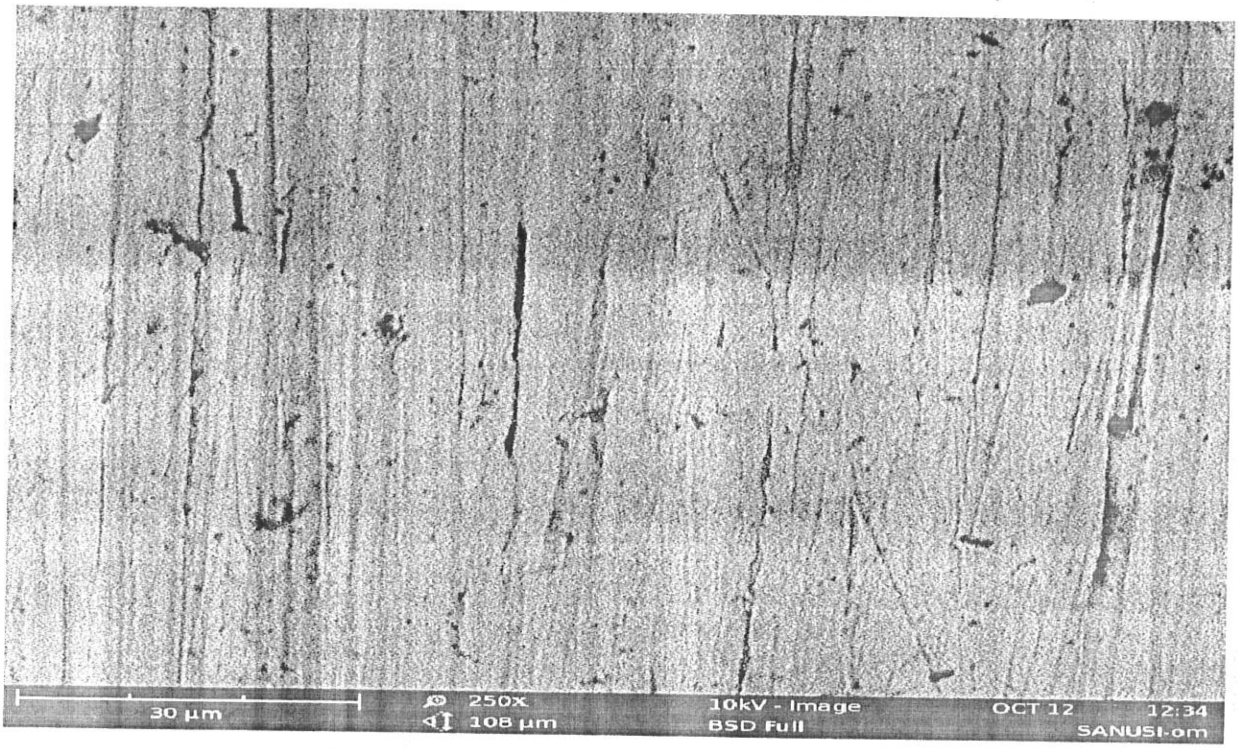


Figure 7 Show the 30% of blend biodiesel of Black date (Atili).

CHAPTER FIVE

5.1 CONCLUSION

After the static immerse of difference section of injector nozzle of diesel engine blends of Black date (Atili) {B10, B20 and B30.}blends with biodiesel concentration of 10% (B10) exhibited not much effect as the loss in weight was negligible within the immersion period. Based on study of corrosion appearance of the injector nozzle in the Black date (Atili) biodiesel blends, presented in this paper, it could be concluded that up to 10% biodiesel content (B10) may be considered suitable for use as motor fuel in Nigeria.

5.2 RECOMMENDATION

It is recommended that for the mechanical characterization of the immerse coupons should be carried out to study the effect of ability on their properties