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INVESTIGATION ON BIOFUEL PRODUCTION USING TWO BASE CATALYSTS

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ABSTRACT

This research is concerned with the conversion of the waste palm oil and jatropha oil to fatty acid methyl esters (biodiesel)by method of trans-esterification with methanol in the presence of sodium hydroxideor potassium hydroxide catalyst (and their combination in varied proportions). For reaction time of 90minutes at a reaction temperature of 60°C and catalyst weight of 1gram, it was observed that maximum yield of 94.8% and 92.6% were obtained from palm oil and jatropha oil at a methanol to oil moleratio of 10:1. All biodiesel samples were tested according to ASTM B100 standards to ascertain their properties as commercially usable biodiesel, and all samples were found to comply with the standards.

KEYWORDS: Waste Palm Oil, Jatropha Oil, Biodiesel, Trans-Esterification

INTRODUCTION

The sky-rocketing price of fossil fuels in the world market and the decline in its supply are the current issues of global concerns that call for a renewable energy sources as complimentary and/or alternatives to fossil fuels. In addition, the problem of the continuous release of huge amount of greenhouse gases (GHG), associated with the utilization of fossil fuels, has triggered climate change. Hence, the quest for an alternative and environment-friendly source of energy has become inevitable for a sustainable future[1]

Alternative energy is the term used to refers to forms of energy that are not based on fossil fuels but are either renewable or sustainable without depleting a finite resource[2]. Examples of alternative energy include geothermal energy, solar energy, tidal energy, wind energy and biofuel.

Adequate energy generation and efficient energy conversion are part of the great challenges experienced in the world, including those associated with sustainability of the environment[3]. Biofuels are attractive alternative/complimentary option to conventional petroleum based fuels as they can be utilized as transportation fuels with little change to current technologies and have huge potential to improve environmental sustainability and reduce the emission levels of GHG.

The current challenge facing the full adoption of biofuel, globally, is its cost implication: it costs more than fossil fuel. Research on improving biofuel production (as energy source) at lesser cost is being intensified[4]. A very promising form of biofuel in this direction is biodiesel, especially if produced from oils that are not suitable for consumption such as waste oils and jatropha oil[5]. Biodiesel (Fatty Acid Alkyl Ester) is produced from the trans-esterification of vegetable oil or animal fats (triglyceride) with alcohol (such as methanol and ethanol), in the presence of a catalyst. It has a relatively high flash point which makes it less volatile and safer to transport or handle than petroleum diesel[6]. It provides lubricating properties that can reduce engine wear and extend engine life[7]. These merits of biodiesel make it a good energy source and have led to its use in many countries, especially in environmentally sensitive areas.

To overcome the problems of very high production cost and starvation resulting from the usage of edible vegetable oil (as triglyceride source), waste vegetable oils and non-edible oils can be used instead[8]. Globally, there is enormous amount of waste vegetable oils generated daily from restaurants, food processing industries and fast food shops[9]. These wastes are being incorporated into the food chain, hence turning into a potential cause of human health problems or pour down the drain, rivers and land resulting into pollution which is very harmful to human health and environment[10]. The oils used in this research work were non edible jatropha oil and waste palm oil and their properties are as shown in Table 1.

Table 1: Properties of Jathropha Oil and Waste Palm Oil Used

Oil	FFA (%)	Sap. Value (mg KOH/g Oil)	Density @ 30^0C (g/cm^3)	Moisture Content (%)
Jathropha Oil	1.26	208.2	0.9178	0.2

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Transesterification of waste oils could be enzyme catalyzed, acid catalyzed, or base catalyzed. Many researchers prefer base catalyzed transesterification for the other two are expensive, especially enzyme catalyzed transesterification[11]. The disadvantages of homogeneous acid catalysis are that it requires a higher reaction temperature (about 200^0C), higher concentration of catalyst, and a longer reaction time due to slower reaction rate. In addition, it is possible to have residual acid catalysts corroding the metal reactor and metal parts of the reactor[12]. The aim of this research is to compare biodiesel yields obtained from waste palm oil and jatropha and to establish optimum conditions for their production.

METHODS

Measured quantity of catalyst was dissolved in methanol to form a clear solution of potassium/sodium methoxide and the mixture was then added to the heated oil. The content was enclosed, continuously stirred at 300 rpm and maintained at $60^oC$for 90 minutes through the use of digital magnetic stirring hotplate. At the end of the transesterification reaction, products obtained were poured into a separating funnel and allowed to settle for 24hours.

The two products obtained were separated (the top layer was biodiesel and the bottom layer was glycerol), the bottom glycerol layer was first drained off and the top biodiesel layer was made purified by the addition of warm distilled water (initially, 2 drops of dilute acid 0.2M H_2SO_4 was added into the distilled warm water. Impurities in biodiesel were removed, dissolved in the warm water and then drained off. Washing was repeated with distilled water only until the water obtained from the separating funnel was clean. The pure but wet biodieselwas dried in an oven at 110^oC for 10 minutes.

DISCUSSIONS OF RESULTS

Biodiesel yield increased steadily as the mole ratio of methanol to oil increased from 5 to 10, regardless of the kind of catalyst used (see Figure 1 and 2). This indicates that increasing methanol/oil mole ratio favours forward reaction of traneseterification process, resulting into increase biodiesel yield. This agrees with research work carried out by Jincheng and Jie[13]. In addition, results obtained showed that the yield is catalyst concentration dependent.

Comparatively, KOH is more suitable as catalyst for transesterification process than NaOH catalyst. This is because KOH catalyst enhanced higher biodiesel yield under the same experimental conditions (Figure 1 and 2). And this finding supports the research work carried out by Khalizani and Khalisanni[14].

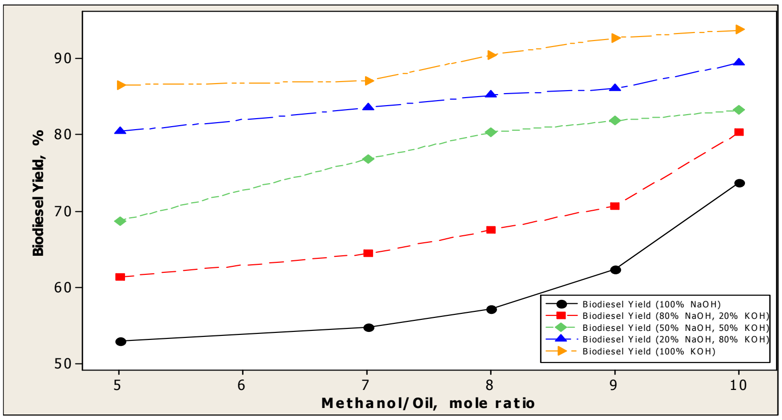

Figure 1: Biodiesel Obtained from Jatropha Oil at Different Methanol/Oil Mole Ratio and Catalyst Mixture

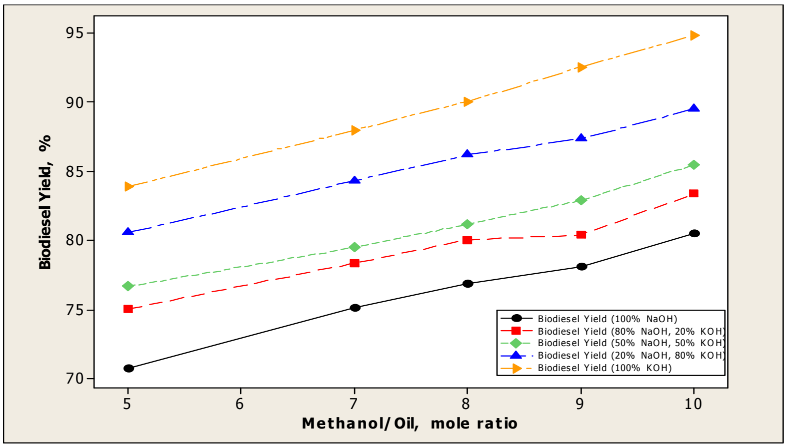

Figure 2: Biodiesel Obtained from Palm Oil at Different Methanol/Oil Mole Ratio and Catalyst Mixture

Effect of catalyst mixture (KOH and NaOH at different proportions) was also considered. The performance of the catalyst mixture (in term of biodiesel yield) increased as the percentage weight of KOH increased for both palm biodiesel and jatropha biodiesel production. That is, biodiesel yield increases with increase in mass fraction of KOH in the catalyst mixture. For instant at methanol/oil mole ratio of 5, yield increased from 75.03 % (20 wt % KOH) to 80.55 % (wt % KOH) for palm biodiesel and from 61.4 % (20 wt % KOH) to 77.4 % (wt % KOH) for jatropha biodiesel.

Comparatively, the palm oil biodiesel yield was higher than jatropha biodiesel under the same reaction condition. This is because triglycerides of palm oil were more reactive than jatropha oil triglycerides due to the fact that the percentage of unsaturated carbon atoms (from fatty acid profiles) in palm oil is higher than that of jatropha.

BIODIESEL PROPERTIES

Analyses were carried out on the biodiesel samples obtained to evaluate its properties and suitability as fuel.

Appearance

It was observed that the appearance of the biodiesel samples produced (from both the waste palm oil and jatropha oil) was bright yellow in colour, but they still retained the initial odour of their parent oils, as reported by many researchers.

Density (@ 30^{0}C)

Density of the jatropha biodiesel produced was within the range (0.8828 – 0.8890) g/cm^3 and (0.8736 – 0.8784) g/cm^3 for palm biodiesel. These are acceptable values when compared to the ASTM specifications[6].

Flash Point

Also measured is another important property of biodiesel, **flash point,** the temperature at which biodiesel burns when in contact with ignition source. The flash point of the jatropha biodiesel produced was within the range (126 – 140) ^{0}C and palm biodiesel flash point range was (123 – 135) °C. These fall within the range of biodiesel flash point standard (ASTM D6751).

Pour Point and Ash Content

The temperature at which crystal agglomeration is extensive enough to prevent free pouring of fluid is called its **pour point**. The pour point values ranges from (3 – 6) ^{0}C for jatropha biodiesel and (3 – 7) ^{0}C for palm biodiesel, fall within the ASTM values of -15 to 10^{0}C. The **Ash content** of the biodiesel obtained from both jathropha oil and palm oil is zero (0). This implies that the biodiesel is fit for use for there was no impurity in the biodiesel.

Cetane Number

Cetane number (CN) relates to the readiness of the fuel to self-ignite when exposed to the high temperatures and pressure in the diesel engine combustion chamber. The cetane number affects a number of engine performance parameters such as combustion, stability, drivability white smoke, noise and emission of CO[15]. The higher the CN, the better the performance of the diesel engine. CN of the palm oil biodiesel ranges from (51 -56) and the range of jathropha oil biodiesel is (49 – 56), these values lie within the ASTM D6751 specification of 48-65.

CONCLUSIONS

Palm oil produced highest biodiesel yield under same experimental condition with palm oil. Qualitatively, biodiesel obtained from jatropha oil was more suitable for utilization, considering the properties of biodiesel obtained.

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