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# The Production of Biodiesel from Human Faeces – A Constituent of Sewage Sludge using Chloroform and N-Hexane

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**ABSTRACT**

The Lipid/oil was extracted from reduced dried primary sewage sludge particle using soxh let extraction method with the mixture of chloroform and n-hexane in ratio 2:1 as the extracting solvent. The extracted oil was transesterified to produce biodiesel. The lipid gave 7.969% percentage yield with density of 0.855g/ml, specific gravity value of 0.855. The chemical analyses revealed acid value of 0.84mg/NaOH/g, free fatty acid value of 0.40% and saponification value was 1.30mg. The lipid/oil was brownish black in colour with a pungent smell.

The physicochemical analyses of the biodiesel produced gave a percentage yield of 32% biodiesel, density of 0.834Kg/ml, pH value of 8.97, specific gravity of 0.834, acid value of 0.29mg KOH/g,saponification value of 1.30 mg, free fatty acid value of 0.145 It is thus apparent that the feedstock (primary sewage sludge) may be a good source for the production of biodiesel.

***KEYWORDS:*** *lipids, primary sewage sludge, biodiesel*

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## INTRODUCTION

The world is experiencing a rapid rise in the demand for biodiesel and other fuels derived from renewable biomass. Biodiesel has long time display potential displacement fuel for petroleum-based diesel fuel. For example, the production of biodiesel in the US has increased from 75 million gallons in 2005 to 250 million gallons in 2006 and 450 million gallons in 2007, with a projected total capacity of well over 1 billion gallons in the next few years (*USDE, 2003*). Nevertheless, this is still a very infant industry compared to petroleum-based diesel. For example, in 2007, the US burned over 60 billion gallons of petroleum-based diesel compared to 450 million gallons of biodiesel (Koplow, 2007).The demand for biodiesel keeps increasing and this has led to an increasing need for lipid feed stocks such as soybean, canola, rapeseed, sunflower, palm, and coconut oils. Currently, biodiesel production cost is on the high side because pure vegetable or seed oils are expensive to use as source. Therefore, the use of alternative non-edible feed-stocks such as Jatropha, animal fats, and waste cooking oil is necessary (Wilson, 2010).

There is a gradual drifting towards using municipal sewage sludge both in the US and around the world as a lipid feedstock for biodiesel production. There are significant concentrations of lipids obtained from the direct adsorption of lipids onto the municipal sewage sludge and energy-containing lipids include triglycerides, diglycerides, monoglycerides, phospholipids, and free fatty acids contained in the oils and fats. More also, the cell membrane of the microorganisms which is composed primarily of phospholipids used in the wastewater treatment process, utilize organic and inorganic compounds in the wastewater as a source of energy, carbon, and nutrients. Studies has shown that 36.8 wt% of the dry sludge is comprised of fatty acids and steroids from an estimated 24% to 25% of dry mass of the cell; and about yields of 7% oil from the dried secondary sludge. The fatty acids from sludge contains the range of C10 to C18, and these are excellent for the production of biodiesel (Fazal, 2011). In the US, it was approximated that 6.2 million dry metric tons of sludge was produced annually by wastewater treatment facilities; and this was expected to increase in the future due to increasing urbanization and industrialization. According to Muhammad, biodiesel is one of the most attractive among the options explored for alternative energy sources (Muhammad and Siddiquee, 2011). Biodiesel production from sludge is a viable alternative to land disposal and this will help to solve both energy and environmental problems. Finally, studies shows that integrating lipid extraction processes in 50% of all existing municipal wastewater treatment plants in the US and trans-esterification of the extracted lipids could produce approximately 1.8 billion gallons of biodiesel, which is also roughly 0.5% of the yearly national petroleum diesel demand (Gerpen, 2004).

Biodiesel comprises of fatty acid alkyl esters (FAAEs) produced via base- and/or acid-catalyzed trans-esterification of lipids using alcohol such as methanol. The physical properties of the resulting biodiesel (e.g., octane number, cold flow, and oxidative stability) are usually determined by the relative amounts of the fatty esters (Knothe, 2010).

This research work, investigates the efficacy of producing biodiesel from sewage sludge by extracting lipids from samples in Udo local government treatment plant, via soxhlet extraction with the mixture of chloroform and n-hexane as solvent; and converting the lipids to biodiesel through transesterification reaction.

**MATERIALS AND METHODS**

**Study Site:**

Solid primary sewage sludge was collected from Udo Local Government waste water treatment plant, Delta State in Nigeria.

**Samples collection and preparation:**

The primary sewage sludge was pre-treated using mechanical method and this involves switching off the connection between the sump and the aerator for about 12 hours therefore allowing the primary sewage sludge to settle underneath the sump before collection. The sample was collected and sun dried for seven days to remove moisture, the dried primary sludge was reduced by using a pestle and a mortar, where it was pounded until it was finally reduced to granule. The reduced particles were weighed using the electronic weighing balance.

**Sample Extraction:**

The reduced primary sewage sludge oil was extracted by soxhlet extraction using the mixture chloroform and n-hexane (2:1) as the organic solvent. The extracted oil was obtained after the organic solvent was removed under reduced temperature and pressure and refluxing at 70$^{o}$C so as to remove any excess organic solvent used for the oil extracted. The extracted oil was stored in refrigerator/ freezer at 2$^{o}$C for subsequent physicochemical analyses (Warra, 2011).

**Physicochemical Analyses of the Extracted Oil:**

Physicochemical parameters were carried out on the extracted oil and they include Percentage yield, pH value, Density, Specific gravity, Saponification value, Acid value/Free fatty acid.

**Production of the Biodiesel:**

The production processes were carried out in two steps and that include the Acid Catalysed Transesterification Process also known as Esterification Process, and the Base catalysed transesterification process. Esterification with the extracted oil was carried out using 95.7ml of methanol and 2.1ml of concentrated sulphuric acid (catalyst). This was heated at a temperature of 60°C for about 1 hour. This process was done in order to reduce the percentage of free fatty acid in the oil (Karaosmanoglu et al., 1996; Lang et al., 2011).

The esterified oil was then transesterified by reacting with 16.1ml of methanol and 1.6ml of sodium hydroxide NaOH (catalyst) and heated at a temperature of 60°C for 1 hour with constant stirring of the mixture using a hot plate magnetic stirrer. After the reaction process, the mixture was transferred into a separating funnel and allowed to settle and cooled while the separation of the two phase layer into the methyl ester phase (Biodiesel) and glycerin phase (Glycerol) as the upper and lower phase occured respectively (Gerpen, 2004).

**Physicochemical Analysis of the produced Biodiesel:**

The biodiesel was further analyzed using ASTM procedure for physicochemical parameters and this includes percentage yield, density, specific gravity, acid value/free fatty acid.

**RESULTS AND DISCUSSION**

The physicochemical analyses carried out on the extracted oil and biodiesel produced are given in Table 1 and 2 respectively.

**Table 1: Results of the Physicochemical Analyses of Extracted Oil**

| Physical Property | Extracted Oil |
|---|---|
| Colour of Oil | Dark brown |
| Smell | Pungent |
| Percentage Yield | 7.684 |
| Density | 0.855 |
| Specific gravity | 0.855 |
| Saponification value | 1.300 |
| Acid value | 0.800 |
| %FFA | 0.400 |

The oil has a brownish black colour and a pungent smell. The percentage yield from calculations was found to be 32.76% and this is smaller when compared to lageneria siceraria seed oil that has a yield of 39.22% (Hassan and Sani,2007). Since sewage sludge can readily be obtained in sufficient quantities, its use as a potential source of lipid for biodiesel production is still encouraging.

Density is expressed as the ratio of the mass or weight (g) of a substance to the volume of the substance (ml). The density of the extracted lipid was found to be 0.834g/ml, being lower than water (1.0 g/ml). Specific gravity is the ratio of the density of a substance to the density of water at 4°C .(Bello and Agge, 2012).]. The extracted oil had a specific gravity of 0.834 (Lang, et al, 2011).

The acid value obtained from the extracted oil is 0.80mgKOH/g and this is smaller than 10.3 mgKOH/g reported for Sheanut butter and higher when compared to 2.455mgKOH/g, 1.265mgKOH/g and 0.82mgKOH/g for castor seed oil, jatropha oil and cotton seed oil respectively. The higher the acid value of an extracted oil, the lower its storage quality and vice-versa, this simply indicates that the extracted oil have better storage quality when compared to that of Sheanut butter oil (Warra,2011).

The free fatty acid value was found to be 0.40% which is smaller when compared to the Hyptusspicigeraseed oil with a value of 3.50% (Ladan,2010). The high FFA (>2%) favours soap formation.

The saponification value of the extracted lipid was found to be 1.30mgKOH/g which is lower than the value of 183.1mgKOH/g for shea-butter oil, 199.95mgKOH/g of cotton seed oil, 126.728mgKOH/g, 125.081mgKOH/g for castor seed oil, jatropha oil respectively, having a potential for soap production (Warra, 2011).

This suggests that the extracted oil will not be a good feedstock for soap making due to its low saponification value (Warra, 2011).

The experimental result of the physicochemical analyses carried out on the biodiesel produced corresponding with the ASTM standard are presented in the table 2.

**Table 2: Physicochemical Analyses of the Biodiesel Produced**

| PARAMETER | ASTM METHOD | LIMITS | RESULT OBTAINED |
|---|---|---|---|
| Color of oil | - | - | Dark brown |
| Smell | - | - | Pungent |
| Percentage yield | - | - | 32.759 |
| pH | - | - | 8.970 |
| Density (g\cm$^3$) | D1298 | 0.830 – 0.900 | 0.834 |
| Specific gravity | D1298/4052 | 0.900 max | 0.834 |
| Acid value | D664 | 0.08 max | 0.290 |
| FFA | - | - | 0.145 |
| Saponification | - | - | 1.300 |

The percentage yield (%) of the biodiesel produced was found to be 32.76% from calculations. The density of diesel fuel is an important property that affects the fuel injection system and high density translates into a high consumption of the fuel. The biodiesel produced has a density of 0.834Kg/ml and a specific gravity of 0.834 which falls within the ASTM standard range at 15$^o$C (Idibie et al, 2020). Acid value is a direct measure of the level of free fatty acids that may be present in biodiesel. The acid value of the biodiesel produced was found to be 0.29mg KOH/g. This shows that the acid value of the biodiesel produced is in agreement with the conventional biodiesel standard which falls in range within 0.50max (Gerpen, 2004).

**CONCLUSION**

With the results obtained, it can be seen that biodiesel is a better alternative fuel than normal diesel fuel. The research work also creates room for further investigation on more physiochemical properties such as cetane rating, viscosity, pour point, cloud point and flash point so as to ascertain the quality of the biodiesel produced from the sewage sludge. From this work, biodiesel produced from lipid extracted from sewage sludge obtained from a treatment plant located in Udu Local government of delta state, shows a promising feedstock for biodiesel production.

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