Biofuel Production from Banana Peels

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Abstract— The high price of different biodiesels and the need for many of their raw ingredients as food materials are the main constraints to be overcome when seeking the best potential alternative fuels to petro-diesel. Apart from that, some properties like high density, viscosity and acid value along with low cloud and pour points preclude their use in compression ignition (CI) engines as these properties can cause serious damage to the parts of the engine and reduce engine life. In this experiment, biodiesel was produced from the oil of unused algae by a two-step 'acid esterification followed by transesterification' procedure. Taguchi's method was applied to design the experiment, and a L25 orthogonal array was prepared to optimize the biodiesel production procedure. The optimized conditions for transesterification were: methanol to oil molar ratio of 6:1, catalyst (KOH) concentration of 2.5 wt%, reaction time of 90 min and reaction temperature of 50 _C, achieving a biodiesel production of 89.7% with free fatty acid content of 0.25%. It was found that the CI engine emitted less CO, CO2 and hydrocarbon and higher NOx using algal biodiesel than that using petro-diesel. All properties of the algal biodiesel were within the limit of ASTM standards. Today, biodiesel, a renewable, non-toxic and environmentally friendly fuel, is attracting increasing attention worldwide as an alternative to fossil fuel. In the present study, waste biomass-derived banana peel ash served as a heterogeneous catalyst for converting soybean oil into biodiesel at room temperature. The catalyst was well-characterized using IR, XRD, XRF, XPS, SEM, EDX, TEM, TGA and BET analysis techniques to assess its chemical composition, structure and morphology. The TEM-EDX, XPS and XRF analyses revealed the presence of several alkali metals and alkaline earth metals, which probably provide the basic sites for the transesterification reactions to produce biodiesel. A high biodiesel yield of 98.95% was achieved under the optimized reaction conditions.

Keywords: Biofuel, Banana Peels

I. Introduction

The current rate of depletion of fossil fuels accompanied by environmental pollution justifies the need for scientists to divert their attention to green and environmentally compatible energy sources. As one of the most targeted sources of energy, biodiesel has shown its supremacy by its ability to undergo degradation and it is also a renewable, affordable, and environmentally friendly source of energy. Having been reported that direct use of plant oil can cause engine problems such as incomplete combustion, high carbon deposit on the combustion chamber, valve seat, and injector nozzle, therefore, biodiesel is a better option to curb these problems as shown by Ahmad et al. Transesterification is the main method that has been used in the production of biodiesel as shown by Meher et al. It is a reaction between oil and alcohol methanol/ethanol) giving out compounds known as alkylesters (methyl/ethyl) accompanied by glycerol as a waste product as shown by Ghadge and Raheman. The intact reaction minimizes parameters such as density, molecular weight, and viscosity and even draws its volatility close to that of diesel fuel by Coniglioet al. For instance, oil from rapeseed (Ramos et al.), soya beans (Gui et al.), sunflower (Antolın), and palm (Crabbe et al.) has gained attention. Unfortunately, the use of edible oils poses a risk in food security and therefore, the current research trends are targeting nonedible oils as the second generation of biodiesel feedstock (Barnwal and Sharma). Various nonedible seeds including neem seed, jatropha, croton, and castor beans have been studied and show good performance in biodiesel production (Atabaniet al.). Neem seeds are derived from unique neem trees that have a long lifespan estimated to lie between 150 and 200 years (Schmutterer). It can bear fruits within 3 to 5 years and attains maximum productivity after 10 years and its oil content varies from 30 to 35% and from 35 to 40% for kernels and seeds, respectively (Kaura et al.) These properties necessitate thinking of it as a suitable feedstock for biodiesel production. It is given that 7 to 8 kg of neem seed produces one litre of oil. It is also worth mentioning in this work that planting of neem trees will address not only energy challenges but also environmental challenges (Kumar and Navaratnam).

II. Literature Review

Ahn et al. followed a two-step reaction process to produce biodiesel. Using this method canola methyl ester (CME), rapeseed methyl ester (RME), linseed methyl ester (LME), beef tallow ester (BTE) and sunflower methyl ester (SME), synthesized in a batch reactor using sodium hydroxide, potassium hydroxide and sodium methoxide as catalysts. Cvengro and Povaz described biodiesel production by using two-stage low-temperature transesterification of cold pressed rapeseed oil with methanol at temperatures up to 70 8C. A new enzymatic method of synthesizing methyl esters from plant oil and methanol in a olventfree reaction system was developed by Masaru et al. In the same year, Uosukainen et al. presented statistical and experimental design to evaluate interdependence of process variables in enzymatic transesterification. The authors also studied the alcoholysis of rapeseed oil methyl ester (biodiesel). Fangrui and Hanna had reviewed the biodiesel production. Samukawa et al. investigated the effects of the pretreatment of immobilized Candida antarctica lipase enzyme (Novozym 435) on methanolysis for biodiesel fuel production from soybean. Ikwuagwu et al. discussed the production of biodiesel using rubber seed oil. The effect of three principal variables namely molar ratio of methanol to oil, amount of catalyst and reaction temperature on the yield of acid-catalyzed production of methyl ester (biodiesel) from crude palm oil had been studied by Crabbe et al.

Kusdiana and Saka discussed the effects of water on biodiesel fuel production by supercritical methanol treatment. Tashtoush et al. conducted an experimental study on evaluation and optimization of conversion of waste animal fat into biodiesel. Ghadge and Raheman studied biodiesel production from mahua (Madhuca indica) oil having high free fatty acids. Van Gerpen discussed the effects of reaction time, reaction temperature on quality and quantity of esters. It is concluded that a trade-off between reaction time and temperature as reaction completeness is the most critical fuel quality parameter. Xu et al. proposed a simplified model to describe the reaction kinetics of the biodiesel production. Cao et al. had carried out transesterification of soybean oil in supercritical methanol in the absence of catalyst.

Ramadhas et al. studied biodiesel production from high free fatty acid rubber seed oil. They developed a two-step transesterification process to convert the high free fatty acid oils to its mono-esters. The major factors affect the conversion efficiency of the process such as BIOFUEL PRODUCTION FROM BANANA PEELS Department of Civil Engineering TSEC Burhanpur Page | 7 molar ratio, amount of catalyst, reaction temperature and reaction duration analyzed. Karmee and Chadha prepared biodiesel from the Pongamia pinnata by transesterification in the presence of potassium hydroxide as catalyst. Ghadge and Raheman discussed the preparation of biodiesel from high free fatty acid oils by using response surface methodology. In the same year, Canoira et al. presented a process to convert the Jojoba oil wax to biodiesel by transesterification with methanol.

Chatpalliwarl, Deshpande, Modak and Thakur (2011) described the brief overview of the Biodiesel production plant. Various issues- sources, opportunities, challenges, plant design, and evaluation etc. are discussed related to the Biodiesel production. Important contribution of the presented work is- it discusses the important issues concerned with the Biodiesel production plant design, it provides the fundamental details required for the formulation of Biodiesel plant design problem, also it presents possible approach for the mathematical model to evaluate the Biodiesel plant design.

Gulab N. Jham et al.(2009) research on wild mustard (Brassica juncea L.) oil is evaluated as a feedstock for biodiesel production. Biodiesel was obtained in 94 wt.% yield by a standard transesterification procedure with methanol and sodium methoxide catalyst. Wild mustard oil had a high content of erucic(13(Z)-docosenoic; 45.7 wt.%) acid, with linoleic (9(Z), 12(Z)- octadecadienoic; 14.2 wt.%) and linolenic (9(Z), 12(Z),15(Z)-octadecatrienoic; 13.0 wt.%) acids comprising most of the remaining fatty acid profile. The cetane number, kinematic viscosity, and oxidative stability (Rancimat method) of the methyl esters was 61.1, 5.33 mm2 s-1 (40 _C) and 4.8 h (110 _C), respectively. The cloud, pour and cold filter plugging points were 4, -21 and -3 _C, respectively. Other properties such as acid value, lubricity, free and total glycerol content, iodine value, Gardner color, specific gravity, as well as sulfur and phosphorous contents were also determined and are discussed in light of biodiesel standards ASTM D6751 and EN 14214. In summary, wild mustard oil appears to be an acceptable feedstock for biodiesel production.

III. MATERIALS PROPERTIES

A. Banana Peel and Its Uses

A banana peel, called banana skin in British English, is the outer covering of the banana fruit. Banana peels are used as food for animals, an ingredient in cooking, in water purification, for manufacturing of several biochemical products as well as for jokes and comical situations.

Bananas are a popular fruit consumed worldwide with a yearly production of over 165 million tonnes in 2011. Once the peel is removed, the fruit can be eaten raw or cooked and the peel is generally discarded. Because of this removal of the banana peel, a significant amount of organic waste is generated. Banana peels are sometimes used as feedstock for cattle, goats, pigs, monkeys, poultry, rabbits, fish, zebras and several other species, typically on small farms in regions where bananas are grown. There are some concerns over the impact of tannins contained in the peels on animals that consume them. The nutritional value of banana peel depends on the stage of maturity and the cultivar for example plantain peels contain less fibre than dessert banana peels, and lignin content increases with ripening (from 7 to 15% dry matter). On average, banana peels contain 6-9% dry matter of protein and 20-30% fibre (measured as NDF) Green plantain peels contain 40% starch that is transformed into sugars after ripening. Green banana peels contain much less starch (about 15%) when green than plantain peels, while ripe banana peels contain up to 30% free sugars. Banana peels are also used for water purification to produce ethanol, cellulose, laccase, as fertilizer and in composting

B. Methanol and Its Uses

Methanol is a nondrinking type of alcohol (also known as wood alcohol and methyl alcohol) which is mostly used to create fuel, solvents and antifreeze. A colorless liquid, it is volatile, flammable, and unlike ethanol, poisonous for human consumption. Methanol, also known as methyl alcohol amongst other names, is a chemical with the formula CH3OH (a methyl group linked to a hydroxyl group, often abbreviated MeOH). It is a light, volatile, colourless, flammable liquid with a distinctive alcoholic odour similar to that of ethanol. A polar solvent, methanol acquired the name wood alcohol because it was once produced chiefly by the destructive distillation of wood. Today, methanol is mainly produced industrially by hydrogenation of carbon monoxide.

Methanol is a promising energy carrier because, as a liquid, it is easier to store than hydrogen and natural gas. Its energy density is however low reflecting the fact that it represents partially combusted methane. Its energy density is 15.6 MJ/L, whereas ethanol's is 24 and gasoline's is 33 MJ/L.

C. Lithium Metal

Lithium compounds, also known as lithium salts, are primarily used as a psychiatric medication. It is primarily used to Treat bipolar disorder and treat major depressive disorder that does not improve following the use of antidepressants. In these disorders, it reduces the risk of suicide. Lithium is taken orally. Common side effects include increased urination, shakiness of the hands, and increased thirst. Serious side effects include hypothyroidism, diabetes insipidus, and lithium toxicity. Blood level monitoring is recommended to decrease the risk of potential toxicity. If levels become too high, diarrhea, vomiting, poor coordination, sleepiness, and ringing in the ears may occur. If used during pregnancy, lithium can cause problems in the baby. It appears to be safe to use while breastfeeding. Lithium salts are classified as mood stabilizers. How lithium works is not specifically known.

IV. Theoretical Investigation

A. Preparation of CBA

Ripe banana peels were sliced into small pieces to accelerate the drying process. After washing with distilled water, banana peels were sundried for 7 days (turned from yellow to black colour became light in weight, hard, and wrinkled) followed by oven-drying at 100°C for6 h. Then, the dried banana peels were ashed in a box muffle furnace in the presence of air and finally milled and sieved to a fine powder. The resulting fine ash was annealed in varying Temperatures at 100°C interval from 550 to 1050°C for 3 h to remove impurities. Finally, the calcined ripe banana peel ash was ground and kept in a seal for further analysis.

B. Making of Heterogamous Catalyst

Calcined banana ash was tested for basicity by dissolving 5g of CBA / LiCaO/ $Fe_2(SO_4)_3$ blends in 50mL of distilled water using pH meter. The blended catalyst metal oxide Li-CaO/$Fe_2(SO_4)_3$/CBA was prepared using 1.3 wt% of lithium calcium oxide (Li-CaO)/iron (III), sulphate ($Fe_2(SO_4)_3$), and 1.7 wt% of CB. Then, 80 mL of methanol was measured using a measuring cylinder and poured in a conical flask. The blended catalyst was dissolved in methanol with continuous stirring of 2700 rpm within 5 min. Then, the solution of the blended catalyst was ready and finally waited for further activity.

C. Neem Seed Oil Preparation

Neem seeds were purchased from Bagamoyo, Iringa, and Singida regions in Tanzania. Initially, the seeds were washed with distilled water and then sundried for five days to remove moisture content, whereas other solid dirty impurities were removed by handpicking and winnowing processes. Seeds were soaked in water for 24 h to remove husks and finally pressed using a hydraulic pressing machine to obtain the oil.

D. Recyclability of the Catalyst

Heterogeneous catalysts have gained fame as compared to homogeneous catalysts because of their reusability. Therefore, the recyclability of the catalyst synthesized in this study was determined as follows. Methanol was used to wash the catalyst spent in the biodiesel production to remove the contents of glycerol and oil. Since water is a product of the transesterification process, the catalyst was later oven-dried for 2 h at a temperature of 110°C. After drying and cooling, the spent catalyst was successfully used to produce biodiesel for the next successive run. Biodiesel yield produced was calculated after every successful run till the fifth run.

V. Result

A. Properties of Algal Biodiesel and Their Corresponding Limits Provided by ASTM

Sr. no.	Fuel Properties	Algal Biodiesel	ASTM standards
1	Acid number, mg KOH/g	0.50	0.50 Maximum
2	Calorific value kJ/kg	40,666	
3	Kinematic viscosity at 40°C, mm2/s	3.16	1.9 to 6.0
4	Relative density at 15°C, kg/m^3	880.5	860-900
5	Flash point, °C	150	93 (minimum)
6	Fire point, °C	153	-
7	Cloud point, °C	1	3(maximum)
8	Pour point, °C	-2.7	-
9	Ash content, %	0.01	0.01 (maximum)
10	Carbon residue, %	0.037	0.50 (maximum)

VI. Conclusion

Continuous supply of diesel or its substitutes has become very important over the last few decades due to rapid industrialization and urbanization all over the globe. Depletion of crude petroleum may result in huge scarcity of this fuel future. The market price of petrodiesel is also increasing for the same reason. So, biodiesel from unused algae might be one solution to the problem as the raw material, for this fuel has no commercial value. Although the algae oil produced in this experiment has a very high FFA content, biodiesel can be produced from it by a twostep procedure. All the properties of this biodiesel were found to be within the limits of ASTM standards. So, no engine modification should be required if diesel–biodiesel blend (with lower per cent of biodiesel) is used. More study is required on engine parts to use pure biodiesel (B100) which is used in CI engines. The high calorific value of this biodiesel indicates that high power would be generated in the engine. This would help to run the engine with less fuel. It was found that only NOx emission for combustion of this biodiesel is higher than that of diesel, whereas emission of other gases like CO, CO_2 along with unburned hydrocarbon, can be reduced many fold if this biodiesel is used instead of petro-diesel. This study presents the production of biodiesel from NSO and affordable solid catalyst synthesized by direct calcinations of banana peels. Calcined banana peels at 650°C acquired good catalytic activity due to the presence of basic metal oxides of K, Ca, Na, and Mg and basic strength of 11.09. The performance was also attributed to its high specific surface area of 411m2/g and pore diameter of 3.0 nm. The maximum biodiesel production yield of 98.8% was achieved at a low catalyst loading of 1.7 wt% and 8 :1 methanol-to-oil molar ratio at a temperature of 60°C. The produced biodiesel acquired physicochemical parameters within the recommended ASTM D6751 standards and it displayed remarkable cold flow properties, that is, cloud point, pour point, and kinematic viscosity, and may be used in cold areas; also the calorific value was high. The catalyst shows good reusability properties with a yield of approximately 75% after a fifth run. It can be concluded that the produced CBA catalyst minimizes waste disposal, hence standing out as an environmentally compatible catalyst.

REFERENCE

[1] http://shodh.inflibnet.ac.in:8080/jspui/bitstream/123456789/360/3/03_literature%20review.pdf
[2] https://en.wikipedia.org/wiki/Banana_peel#:~:text=A%20banana%20peel%2C%20called%20banana,for%20jokes%20and%20comical%20situations.
[3] https://www.google.com/search?q=methanol&rlz=1C1FHFK_enIN941IN941&oq=METHANOL&aqs=chrome.0.69i59j0j0i433l2j0l3j69i60.29510j1j4&sourceid=chrome&ie=UTF-8
[4] https://en.wikipedia.org/wiki/Iron(III)_sulfate
[5] https://en.wikipedia.org/wiki/Lithium_(medication)
[6] https://en.wikipedia.org/wiki/Calcium_oxide#:~:text=Calcium%20oxide%20(CaO)%2C%20commonly,crystalline%20solid%20at%20room%20temperature.
[7] https://en.wikipedia.org/wiki/Phenolph10thalein#:~:text=Phenolphthalein%20is11%20often%20used%20as,dyes%20known%20as%20phthalein%20dyes.
[8] https://en.wikipedia.org/wiki/bio_fuels
[9] https://en.wikipedia.org/wiki/Biodiesel_production#:~:text=Biodiesel%20production%20is%20the%20process,be%20of%20low%20molecular%20weight
[10] https://www.hindawi.com/journals/amse/2020/7825024/