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Green Chemistry for Low Carbon Emission and Healthy Environment

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Abstract Environmental pollution is responsible for Green House Gas emission (GHG) and climate change hence, replacing fossil fuel with bio-based materials (Renewable feedstock) is currently been embraced so as to mitigate carbon emission. About 170 billion tons of biomass is generated yearly and approximately 5.95 billion are utilized. Hence, this paper examines the use of Renewable energy and Renewable feedstock (Biomass). Newly developed heterogeneous catalysts were developed from waste agricultural residues. Caustic potash was extracted from the ash samples of Cocoa pod husk (*Theobroma cacao*) and Palm kernel frond (*Elaeis guneensis*) and used to catalyse the conversion of *Jatropha curcas* oil to biodiesel with encouraging results. Extracted potash from the two waste residues was 28.0% (Cocoa Pod husk) (CPH) and 24.3% Palm kernel frond (PKF).The percentage biodiesel yield of CPH was significantly difference ($P<0.05$) from that of Commercial KOH. There was no significant difference ($P>0.05$) in the specific gravity between CPH and the commercial KOH. The flash point and saponification values were highly significantly in CPH. The fatty acid composition was better in CPH compared with the commercial KOH. In conclusion, this study revealed the development of a new comparable catalyst from waste agricultural residues (CP H and PKF) hence, the new innovative technology should be embraced so as to convert waste to wealth and have clean environment.

Keywords Renewable feedstock, biodiesel, cocoa pod husk, palm kernel frond, briquette

1. Introduction

Humans have a large impact on the global environment and our population has grown explosively, along with our use of energy and resources. Human population reached 6.8 billion in 2010, more than double the number of people in 1960. (https://schoolworkhelper.net/population-growth-regulation-geometric-logistic-exponential). There is the need for more energy for the teeming population.

The demand for energy must be met in a way that is eco-friendly and economical. Petrochemical have been the backbone of the chemical and energy industries therefore there is the need to make transitional transformation to biological sources and integrate the new technology in the prevailing industries so as to mitigate current environmental polluted processes (Green Chemistry).

Green Chemistry is a unique branch of Chemistry that deals with Innovative Research on the development of alternative sustainable technologies (Innovations and Green Chemistry). Green Chemistry is a diverse discipline with the ultimate aim of reducing wastes, eliminating hazardous waste disposal, allowing use of waste products and finally reduce/eliminate the use of petroleum products.

It is with the aims that the Twelve Guiding Principles of Green Chemistry was noted by Anastas and Warner [1] thus: Prevention—it is better to prevent than to treat /clean up; Atom economy—synthetic method should be designed to maximise the incorporation of all materials used in the processing of final products; Less hazardous chemical synthesis—little/no production of toxic materials to the environment; Designing safer chemicals; Safer solvent and auxiliaries; Design for energy efficiency; Use of renewable feedstock ;Reduction of derivatives; Catalysis-catalytic reactions are superior to stoichiometric agents; Degradation-chemical products should be degradable; pollution prevention; Inherently safer chemistry for accident prevention.

It interesting to know that about 170billion tons of biomass are produced yearly and 100 x 109 tons of cellulose annually. Hence, only about 3.5% are used while the remaining are wasted causing pollution [2]. Biomass offers a renewable and sustainable source of carbon in form of biopolymers (cellulose, starch, lignin, hemicellulose and monomeric (carbohydrate, oil, amino acids and plant extract) [3]. It is more flexible, mitigate carbon emission. Examples of Renewable Feedstock (Biomasss) are Cocoa Pod Husk (CPH) and Palm Kernel Frond (PKF).

Figure 1: Cocoa Tree with Pod

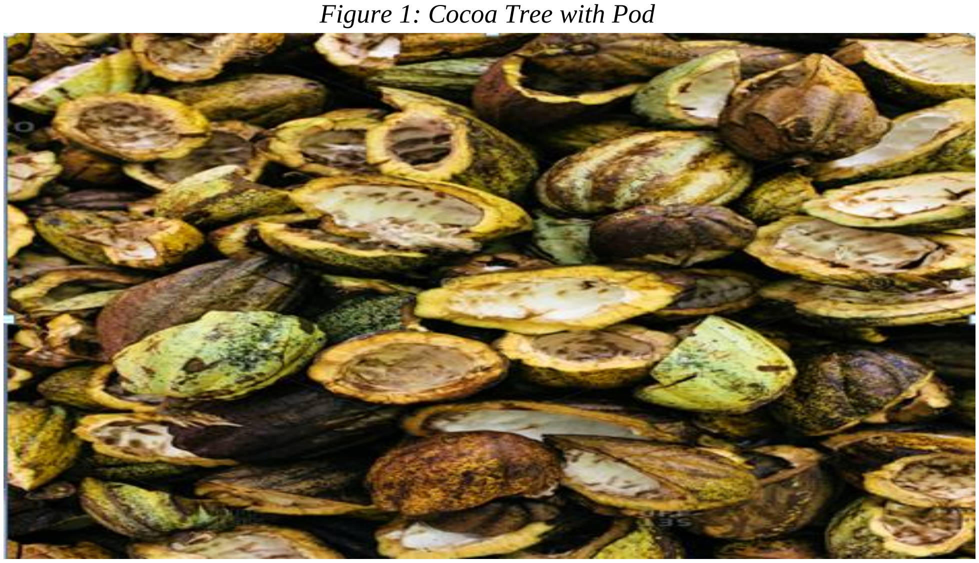

Figure 2: Cocoa Pod Husk

Cocoa (*Theobroma cacao*): It is an important export cash crop in West Africa especially, Nigeria. It contributes to the foreign exchange earning of Nigeria. Cocoa Pod Husk (CPH) which is about 80% of Cocoa fruit is a by-product of Cocoa processing Industry after the extraction of the beans. About 800, 000 tons of CPH are generated and wasted yearly in Nigeria [4]. Ayeni et al. [4] noted that CPH contained N:P:K) calcium, magnesium and micronutrients.

Figure 3: Oil Palm Tree

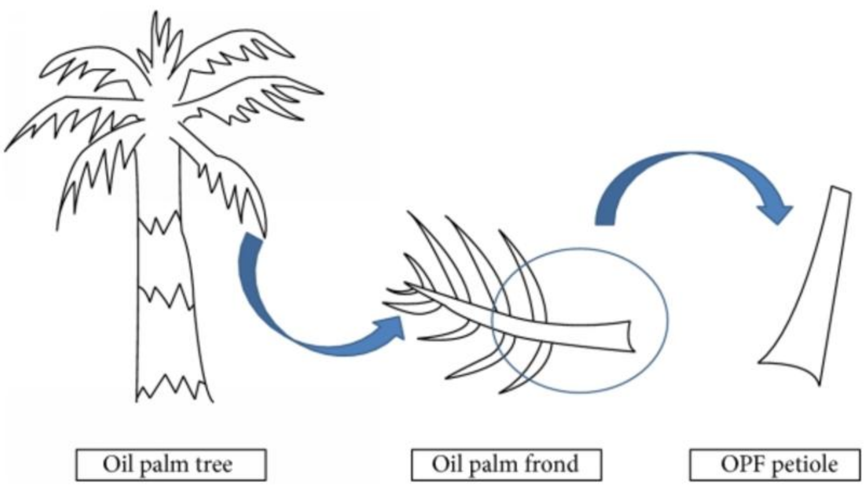

Figure 4: Oil Palm Frond

OIL PALM (*Elaeis guneensis)*: The plant grows well in the tropical environment. Its importance could not be overemphasised. The frond is one of the essential parts of the plant among others (palm wine, palm oil, palm kernel, broom, palm kernel cake). It was noted that the frond is rich in potash [4]. The thrust of this study was to evaluate the efficacy of Cocoa Pod Husk (CPH) and Palm Kernel Fronds (PKF) as novel alternative catalyst in the production of Jatropha biodiesel.

Materials and Methods

Site of the Experiment

The experiment was conducted at the Department of Chemistry, University of Ilorin, Nigeria. University of Ilorin is located in the central part of Nigeria with a temperature of between 24 degree Celsius and 33degree Celsius, humidity of 38 –80%. It has latitude of 8.4813 degree N and a longitude of 4.6115 degree E. with seven months of rainfall and five months of dry period [5].

Collection and Preparation of Samples

Cocoa Pod Husk and Palm Kernel Frond were collected from Kogi State in Nigeria. The samples were washed with distilled water and later sundried for about one week before milling. The dried samples were milled using hammer mill. The milled samples were kept in muffle furnace (600 ºC) for 6 hours for ashing. It was allowed to cool and latter milled and smoothened

Determination of the Concentration of Potash

20g each of CPH and PKF ash was weighed separately into a round bottle flask and a litre of distilled water was added to the flask containing the ash respectively. The mixture was allowed to stand for about a week after which it was filtered by suction. The resulting solution was titrated against 0.1M HCl solution using methyl orange as indicator [6].

Production of Jatropha Biodiesel

Jatropha oil extracted from Jatropha seed was converted into biodiesel using the modified method of Ugbeoke *et al*. [7].

Chemical and Physical Analyses

Specific gravity –determined using specific gravity bottle.

Viscosity----determined by using Brookfield Digital Viscometer (Model DV-1-DVTD).

Saponification, Acid and Iodine----determined by the method of BPC (1988).

Peroxide and Free fatty acids---determined using titration method as prescribed by AOAC (1990)

Flash Point ---- determined by using Pensky-Marten apparatus

Fatty Acids of the Biodiesel

The fatty acid component of the biodiesel was determined using GC equipped with Flame ionization detector and capillary column (HP I NNOWAX (30m x 0.25nm x0.25µm).

About 0.1ml of the biodiesel was injected into the GC. The detector temperature was programmed at 320 degree Celsius with flow rate of 0.8ml/ min for 60 minutes. A temperature of 250 degree Celsius was set for injector and nitrogen was used as a carrier gas.

The peak identification was achieved by retention times and comparing them with authentic standards analysed under similar condition.

Statistical Analysis

All data collected was analysis using Student 'T' test and Analysis of variance of a Completely Randomised design model while significant means were separated using Duncan (1955) Multiple Range Test.

Results and Discussion

Table 1 showed the Caustic potash content and Ash yield (%) of CPH and PKF. The ash yield was significantly higher in PKF than CPH however, the results revealed that KOH content of CPH was significantly ($P < 0.05$) higher than that of PKF. This supported the submission of earlier researchers [8-10] that CPH is richer in potassium.

Table 1: Extraction (%) of KOH from CPH and PKF

Parameters*	**Cocoa Pod Husk (CPH)**	**Palm Kernel Frond (PKF)**
Initial weight (g)	198.97^b	254.57^a
Ash yield (%)	52.54^b	65.80^a
%Potash	28.00^a	24.30^b

Means along the same row having similar superscripts are not significantly different ($P>0.05$) from each other

• Means of 10 determinations

Table 2: Physico-chemical Parameters of Biodiesel made using Potash from CPH, PKFand Commercial KOH

Parameters	CPH Biodiesel	PKF Biodiesel	Commercial KOH
Yield (%)	85.33[a]	66.00[b]	82.00[a]
Moisture (%)	0.70[a]	0.30[b]	0.01[c]
Specific gravity	0.79	0.80	0.89
Density (g/ml)	0.87	0.88	0.89
Acid value	8.82[b]	2.98[c]	180.6[a]
Iodine value	9.76[b]	5.78[c]	38.36[a]
Saponification value	210.76[a]	211.3[a]	242.53[b]
Viscosity value (mm^2s^{-1})	4.12[b]	3.51[b]	10.70[a]
Refractive index	1.54	1.57	1.56
Flash point	211 ºC	211 ºC	210 ºC
pH	6.62	6.50	5.32

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Means along the same row having similar superscripts are not significantly differently (P>0.05) from each other.

Table 3: Fatty acids Composition of Biodiesel made Using Cocoa Pod Husk (CPH), Palm Kernel Frond (PKF) and Commercial KOH

Fatty acids	**CPH**	**PKF**	**Commercial KOH**
Oleic acid (18:1)	53.81[a]	57.77[a]	46.70[b]
Linoleic acid (18:2)	19.78[b]	21.06[b]	33.90[a]
Palmitic acid (16:0)	24.49[a]	19.90[b]	14.80[c]
Stearic acid (18:0)	0.50[b]	0.69[a]	0`72[a]
Linolenic acid (18:3)	0.39[b]	0.48[a]	0.25[c]
Arachidic (20:0)	1.98[a]	1.85[a]	0.25[b]
Erucic	23.2[a]	0.19[b]	0.22[a]
Saturated	27.10	22.53	22.70
Monounsaturated	53.10	57.00	46.50
Polyunsaturated	21.15	22.32	34.10

Means along the same rows having similar superscripts are not significantly different (P>0.05) from each other.

The biodiesel using CPH potash gave significantly (P<0.05) higher yield and flash point compared to that of PKF and that of commercial KOH. There was no significant difference in the saponification value, pH, specific gravity and density and are comparable to KOH.

Fatty acid composition is shown on Table 3. Oleic acid, Palmitic acid, linolenic acid, arachidic acid and monounsaturated were significantly (P<0.05) higher in the biological prepared potash compared with the commercial KOH.

Every vegetable oil is a prospective feedstock for the production of biodiesel but the quality of the fuel is dictated by the composition of the oil.

Conclusion and Implications

Biodiesel is eco-friendly hence; it attracts the attention of various countries.

Using feedstock (CPH and PKF) from abundantly waste agricultural residues (30,000 ton) to prepare functional bi-product thereby contributing to energetic transition should be embraced so as to reduce waste, eliminate hazardous waste disposal thereby resulting in clean environment.

Acknowledgments

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