Biofuel production from wood shavings

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ABSTRACT

In this study, wood shavings were sourced from a sawmill in Ibadan, Nigeria and treated to a 12% moisture content for size reduction using a hammer mill. A measuring balance was used to weigh the samples in increments of 1kg, and the wood shavings were processed with the assistance of the hammer mill for size reduction. The particles were then passed on to a pre-treatment chamber where water and tetraoxosulphate VI acid were added to the blend. The mixture was then pumped into a fermentation chamber where heat was introduced by a heater up to 100°C. The experiment was conducted for various masses of wood shavings, and the amount of biofuel produced was measured in liters. The efficiency of the hammer mill was 84.6%, with a throughput capacity of 13.63 kg/hr. The mean efficiency of the pre-treatment chamber was calculated to be 82.29% with throughput capacity of 38.4 kg/hr. The final product, ethanol, was assessed for its physical and chemical properties in a laboratory setting, and it was found to be combustible and supported ignition. The amount of ethanol produced increased with the amount of feedstock used.

Key Words: *Wood shavings; Biofuel; Moisture content; Production plant*

INTRODUCTION

It is important for engineers and scientists not to rest on the search for alternative energy sources across the globe as fossil fuel continues to deplete every day, this is making the price of gasoline rise almost every day the world over. This research work majorly focuses on the extraction of biofuel from wood shavings with the help of a biofuel production plant.

Nwakaire investigated the age of cellulosic ethanol from wood sawdust in an examination office scale [1]. This work as such was finished utilizing an area available biomass misuse as an elective wellspring of ethanol, which is correct currently used as a piece of begin engines as a supportable power source fuel. It furthermore chose the yield of ethanol from the sawdust used. The sawdust test was assembled from the Nsukka Sawmill (Timbershade). Materials used incorporate 18 m (78% center) of sulfuric destructive, 6 m of sodium hydroxide for hydrolysis, and maturing strategy. Hydrolysis incorporates the extraction of fermentable sugar from cellulosic biomass. The sawdust of the sulfuric destructive mix was allowed to sit for 48 hours, by then the refined water was used to debilitate with a particular ultimate objective to bring its pH between 5.0-6.0. 10 kg of sawdust gave 500 cm^3 of ethanol using the Beer-Lambert plot of the ethanol-water mix. The accomplishment of the extraction of ethanol shows up there with potential results for advancement.

The examination of ethanol yield conveyed from dissimilar crops exhibits that cassava has the most amazing biofuel yield of 6,000 kg per hectare per year and the most critical change rate of 150 Liters per tonne of all the essential crops [2]. Regardless of the way that sugar sticks and carrots have higher gather yield of 70 tons/ha/yr and 45 tons/ha/yr independently appeared differently about 20 tons/ha/yr for cassava, the enormous measures of water, which they require amid their formative periods is a strong control when stood out from cassava which can truly create under extensively drier conditions. The researcher saw that an immense measure of new cassava tubers yields around 150 liters of ethanol [3].

MATERIALS AND METHODS

Materials

The study makes use of the following materials; 100 kg of wood shavings, weighing balance, biofuel production plant, concentrated tetraoxosulphate vi acid (H_2SO_4), 30 liters of water, and a stopwatch.

Methods

Wood shavings were sourced at the New Garage sawmill, Ibadan Oyo State, Nigeria. The wood shavings utilized were gathered and treated to 12% moisture content keeping in mind the end goal to permit simple exchange from the hammer mill to the conveyor. A measuring balance was utilized to weigh the feedstock in 1 kg, 2 kg, 3 kg, 4 kg, and 5 kg respectively. Each of the samples was processed with the assistance of the hammer mill for size reduction.

The wood shavings were weighed with measuring balance and will be stacked into the hammer mill, in which the 5 HP electric engine will be exchanged for the size decrease of the feedstock. The particles were passed on to the pre-treatment chamber while the water and tetraoxosulphate VI acid was added to the blend. The blend will be altogether mixed and pumped into the fermentation chamber where warmth will be acquainted with the framework with the assistance of the heater up to 100°C. While the copper gathering channel (condenser) will be going through the buildup chamber for cooling and after that to the ethanol collection chamber.

The experiment was continued for various masses of wood shavings, which was recorded with the retention time with the assistance of the stopwatch, and the amount of biofuel from the feedstock was estimated in liters [4].

Nasir technique for effectiveness and efficiency for hammer mill machine was embraced for evaluation of the milling machine (Table 1).

$$Milling\ Efficiency = \frac{Milling\ Efficiency}{Mass\ of\ input\ feedstock} \times 100 \quad (1)$$

To determine the losses that occur during the milling operation.

$$Losses = \frac{M_b - M_a}{M_b} \quad (2)$$

Where

Mb=Mass of feedstock before milling

Ma=Mass of feedstock after milling

To calculate ethanol content by % volume=volume of the product x mass x density (3.26).

$$Volume = \frac{Mass}{Density} \quad (3)$$

Milling or crushing capacity is defined as the mass of material ground in kg/hr.

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RESULTS AND DISCUSSION

Influence of age and sex on the prevalence of onchocerciasis and loiasis in the study population

The machine which was loaded with 1 kg of wood shavings at 12% moisture content through the feed hopper, produced 0.76 kg feedstock after milling operation within 252 seconds at 76% efficiency. Following the successful completion of mass 1 kg feedstock, the same procedure was followed for mass 2 kg, 3 kg, 4 kg, and 5 kg, with their corresponding output of 1.62 kg, 2.34 kg, 3.56 kg, and 4.40 kg respectively. The milling duration recorded during the operation was 426.0 seconds, 673.8 seconds, 948.0 seconds, and 1044.0 seconds with efficiencies of 81%, 78%, 89%, and 88% respectively [5-7].

Table 2 revealed the machine performance with a mean mass of the feedstock (wood shavings) before milling is 3.0 kg with a mean output of 2.54 kg. This implies that the efficiency of the developed hammer mill is 84.6 % with a percentage loss of 15.3% respectively, with a throughput capacity of 13.63 kg/hr. From the test result obtained it is obvious that an increase in the quantity of feedstock loaded is corresponding to an increase in the quantity of output and even the efficiency of the machine. The reason for this is that the particles milled have to be transferred through the suction pump of the cyclone to the pre-treatment chamber, this usually increases the pressure of the hammers in the machine compartment. The milling of the feedstock was achieved through the constructed hammer mill, while the cyclone developed was employed in transferring the particles in the pre-treatment chamber of the plant [8,9].

The mean efficiency of the pre-treatment chamber was calculated to be 82.29% with a throughput capacity of 38.4 kg/hr as revealed in Table 3. Change in temperature of the feedstock occurs because of the mechanical agitation of the feedstock by the stirrer, with the temperature ranging from 25.20°C to 38.30°C. The input slurry was recorded between the range of 6.02 kg to 21.65 kg, while the output slurry ranges between 4.98 kg to 19.20 kg respectively. Since there are recordable increases in the temperature of the slurry, this has shown that there is a breakdown of the lignocellulose materials in the feedstock.

TABLE 1
Bill of engineering materials and evaluation for the production

S/No	Description	Specification	Quantity	Cost (₦)	Total Cost (₦)
1	Wood Shavings	100 kg	100 kg	10	1,000
2	Sulphuric Acid	Conc.	5 liters	1000	5000
3	Fuel for Generating set	Diesel	10	750	7500
4	Transport and Labour			10000	10000
25	Miscellaneous			10000	10000
	Total Cost				₦33,500

TABLE 2
Result for the milling of the feedstock (wood shavings)

Trial	Mass of feedstock before milling (kg)	Mass of feedstock after milling (kg)	Duration of Milling Operation (Second)	Percent Losses (%)	Efficien-cy (%)
1	1	0.76	252	24	76
2	2	1.62	426	19	81
3	3	2.34	673.8	22	78
4	4	3.56	948	11	89
5	5	4.4	1044	12	88
Total	15	12.68	3343.8		
Mean	**3**	**2.54**	**668.8**	**17.6**	**82.4**

TABLE 3
Test for the pre-treatment wood shavings

Mass of wood shavings (kg)	1 Kg	2 Kg	3 Kg	4 Kg	5 Kg
The volume of Water V_1 (ml)	5000	7500	10000	12500	15000
H_2SO_4 V_2(ml)	35	70	105	140	175
Duration t (mins)	10	15	20	25	30
Initial Temperature T_1 (°C)	25.2	27	27.5	29.8	30.2
Final Temperature T_2 (°C)	28	30.3	32	35.7	38.3
Input Slurry (kg)	6.02	9.69	14.68	16.9	21.65
Output Slurry (kg)	4.98	7.24	12.02	14.1	19.2
E iciency (%)	82.72	74.72	81.88	83.43	88.68

The table above revealed the preliminary test of the constructed ethanol fermentation chamber. The quantity of ethanol obtained from the feedstock increases about the increase in the wood shavings. Table 4 shows that from 1 kg mass of wood shavings, there will be 0.256 liters of ethanol with the addition of 35 ml of concentrated Tetraoxosulphate VI acid (H_2SO_4) with a heating period of 30 minutes. Furthermore, the amount of biofuel obtained from the wood shavings increases as the quantity of the feedstock increases. With a mass of wood shavings at 5 kg, the amount of ethanol obtained increases to 1.534 liters with the addition of 175 ml of concentrated Tetraoxosulphate VI acid (H_2SO_4) over 150 minutes of heating.

It was also recorded that the boiling point temperature for vapor formation that later leads to ethanol production was 82°C, which was later regulated by the use of a thermostat to 60°C over the time used in the production process. The result obtained is the following where the author research on laboratory production of ethanol from the Iroko tree. The researcher also reported that the amount of feedstock will also determine the amount of ethanol produced. The only thing is that it takes seven days before he can produce ethanol because of the laboratory preparation while the pilot scale takes only 30 minutes for production.

The qualities of some physical and chemical properties were assessed to affirm the liquid produced to be ethanol. The fluid created is dismal with a sweet smell. The ethanol acquired was additionally subjected to basic tests in the research facility. The flame was noticed as the liquid was put nearer to the fire and it demonstrated that the ethanol acquired is exceptionally combustible and backings ignition.

Table 5 above uncovered that the higher the amount of feedstock the higher the measure of ethanol created. The properties of the fluid got were resolved at the Federal College of Agriculture, Ibadan liquid mechanics research center. The pH was 7, the breaking point was 82.0°C and the relative thickness of the fluid delivered was 0.791 g/cm^3. These qualities fit in with the standard properties of ethanol as appeared in Table 4 [10].

The ANOVA table revealed the results of the statistical test used to determine if there are significant differences in the means of production of biofuel from wood shavings across five different groups (Col 1-5). The table shows the number of observations (count), the sum, average, and variance of each group.

The ANOVA source of variation shows the Sum of Squares (SS), Degrees of Freedom (df), Mean Squares (MS), F-value, P-value, and F critical value. The F-value compares the ratio of variation between groups to the variation within groups, and the P-value is the probability of getting an F-value as large

TABLE 4
Quantity of liquid biofuel obtained from wood shavings

Mass of wood shavings (kg)	1	2	3	4	5
Input Slurry (kg)	4.98	7.24	12.02	14.1	19.2
Mass of biofuel (kg)	0.202	0.587	1.034	1.089	1.21
H_2SO_4 (ml)	35	70	105	140	175
Duration (mins)	150	155	159	162	163
Volume of biofuel (L)	0.256	0.744	1.311	1.38	1.534
Density of ethanol= 0.789 kg/L					

TABLE 5
Determination of the liquid properties obtained

Liquid	pH	Melting point (°C)	Vapourisation point (°C)	Density at 20°C
Ethanol	7	--- 114.1 °C	78.5 °C	0.789
Ethanol produced	7		82.0°C	0.791

TABLE 6
Analysis of variance for production of biofuel from wood shavings (SUMMARY)

Groups	Count	Sum	Average	Variance
Col 1	4	236.7	59.175	1504.476
Col 2	4	246.7	61.675	1583.316
Col 3	4	247.7	61.925	1543.509
Col 4	4	254.7	63.675	1582.943
Col 5	4	251.9	62.975	1493.949

TABLE 7
Analysis of Variance for production of biofuel from wood shavings (ANOVA)

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	47.128	4	11.782	0.007643	0.999869	3.055568
Within Groups	23124.58	15	1541.639			
Total	23171.71	19				

or larger than the one observed, assuming the null hypothesis is true (Tables 6 and 7).

In this case, the P-value (0.999869) is very high, which indicates that there is not a significant difference in the means of production of biofuel from wood shavings across the five groups. The F-critical value (3.055568) is also not met, further supporting the conclusion that there is no significant difference.

The result simply implies that the effect of input parameters which include the feedstock, water, and H_2SO_4 had no significant difference at R2=0.999. The temperature at the vaporization point significantly ($p<0.005$) influences the mass of the feedstock.

CONCLUSION

From the result obtained from this research work; it has been established that alternative fuel can be obtained from waste of the wood (wood shavings) when subjected to certain operations which include; size reduction, pretreatment which is the hydrolysis stage, fermentation, and condensation. The inference drawing from the fieldwork has revealed that the above-listed procedure is standard for the production of biofuel through the integrated facility.

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