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Production and Performance Evaluation of Biofuel Obtained from *Artocarpus heterophyllus* Waste

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Abstract

Biofuel production from agricultural and fruit wastes is one of the major solutions towards the generation of renewable energy and the management of waste. Production of low-cost second generation Biofuel from lignocellulosic fruit wastes of Artocarpus heterophyllus was carried out by saccharification and fermentation process. Baker's yeast was used for fermentation as it gives a high yield of bioethanol. Reducing sugars in the pretreated sample at different acid concentrations was found using the DNSA Method. The process optimization was carried out by varying fermentation temperatures to obtain a high bioethanol yield. The produced bioethanol was extracted by distillation process. The bioethanol obtained was tested for its efficiency in a four-stroke single-cylinder petrol engine Test Rig. The bioethanol was blended with petrol in different proportions. The results obtained indicate the addition of bioethanol to petrol can reduce harmful combustion gases thereby contributing to decreasing pollution. It also improves brake thermal efficiencies and reduces the consumption of fuel. The fuel combustion properties and Calorific Value of the petrol bioethanol blend were also determined.

Keywords: *Artocarpus heterophyllus, Biofuel, Fermentation, Fire Point, Flash Point, Test Rig*

1.0 Introduction

Biofuels produced by anaerobic digestion have advantages over fossil fuels obtained from geological processes. Fossil fuels emit a lot of oxides of carbon which leads to pollution and global warming. Replacing fossil fuels with biofuels *viz*., bioethanol or biodiesel can contribute to abating pollution and global warming to a greater extent as they are carbon neutral[1]. Biofuels can be profitably produced from biomass obtained from agricultural wastes, kitchen wastes, fruit, vegetable wastes, seaweeds etc[2,3]. The conversion of biomass into biofuel can be carried out by chemical or biochemical conversion methods or by a high-temperature digestion process. The biofuel obtained from the above process can be in solid form, liquid form or in gaseous form. But the most commonly obtained fuel is in liquid form[4,5].

During the fermentation process, sugar and starch are produced by the carbohydrates present in biomass. The biomass consists of carbohydrates which on fermentation yields bioethanol which is the most widely synthesised biofuel from agro wastes[6]. Bioethanol can be produced by digestion of enzymes and sugar fermentation followed by distillation. Bioethanol can be used alone or in combination with petrol in proper proportions[6,7].

In this research work attempts are made to synthesise Bioethanol from wastes of *Artocarpus heterophyllus*. The testing of synthesised bioethanol was carried out in a test rig with different compositions of bioethanol and gasoline.

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2.0 Materials and Methods

Wastes of *Artocarpus heterophyllus* obtained from the local market were washed with water, cut into small pieces, dried in the sun and pulverised into fine particles. All the chemicals used were laboratory grade and double distilled water was used for sample preparation.

The steps involved in the process are given below:

Step 1: The substrate was subjected to pre-treatment by acid hydrolysis[8] to reduce cellulose to sugar in an autoclave.

Step 2: Qualitative and quantitative estimation of reducing sugars was carried out by DNS method[9,10], Iodine testing[11] and Benedict test[12].

Step 3: Saccharification and fermentation[13] using saccharomyces cerevisiae to produce bioethanol.

Step 4: Engine performance test in four-stroke single-cylinder petrol engine test rig[14].

Step 5: Determination of combustion characteristics of bioethanol and petrol blend.

Step 6: Determination of fuel properties of bioethanol.

2.1 Fermentation and Distillation

A known amount of peptone was added to lukewarm water in a beaker. 10g yeast is added to lukewarm water in another beaker. Both these solutions are added to the hydrolysate obtained. The pretreated samples are collected in a large bottle of 10 litres. The prepared fermentation medium was added to the sample one by one and mixed thoroughly. The bottle was then kept for fermentation in a BOD incubator at 30°C for 3-5 days under anaerobic conditions. The filtrate after the fermentation process was distilled twice using a Soxhlet Apparatus. The solution was then loaded into a distillation flask of the Soxhlet Apparatus. The temperature was set to 78° C. Ethanol being volatile at this temperature evaporates and condenses into the inner vessel of the Soxhlet Apparatus. The Distilled sample was tested for fuel properties and engine performance evaluation. The overall procedure adopted for the synthesis of bioethanol is provided in Figure 1.

3.0 Results and Discussions

3.1 Estimation of Reducing Sugar and Primary Alcohol

Reducing sugar content was estimated by using the DNSA method. Samples that are acid hydrolysed with 1%, 2%, 3% and 4% H_2SO_4 acid are used for the estimation of reducing

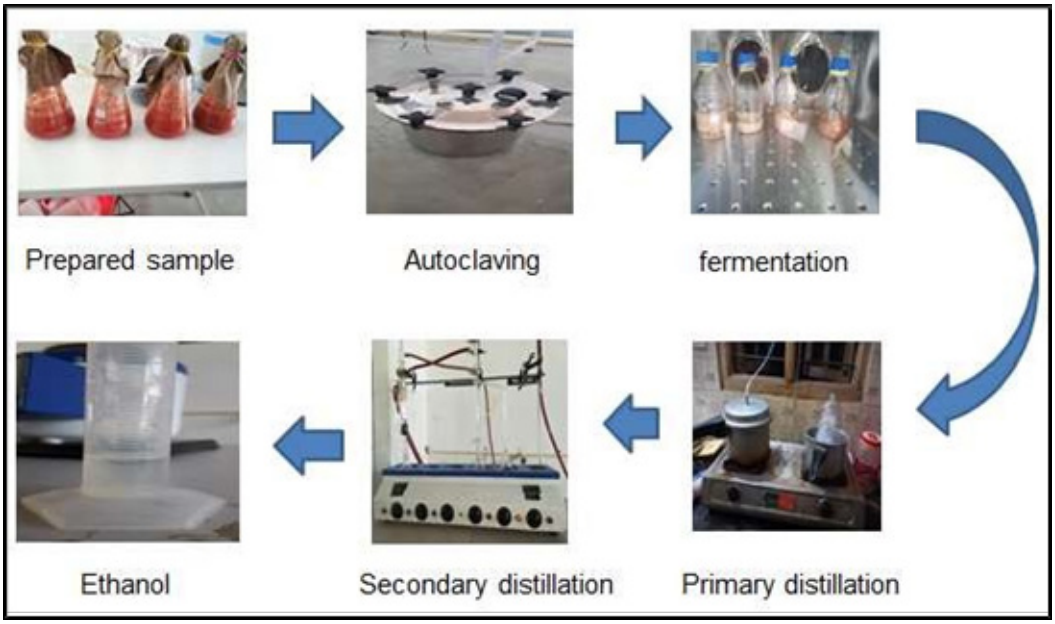


Figure 1. Pictorial representation of bioethanol production.

sugars. Table 1 presents the amount of glucose estimate with respect to Sulphuric acid concentration. It can be observed that glucose content in the sample increased with an increase in the acid concentration to 3% and decreased with a further increase in acid concentration as hydrolysis is affected due to higher acid content.

Table 1. Estimation of glucose.

Percentage of Sulphuric Acid (%)	Amount of Glucose (mg/dl)
1	48
2	125
3	222
4	150

The iodine test was conducted by adding 2-3 drops of iodine solution into the prepared test solution. A blue-black colour formed indicates the presence of sugar in the sample. Similarly, Benedict's test was conducted by adding Benedict's reagent. Brick red precipitate formed during the test signifies the presence of reducing sugar in the solution.

Qualitative estimation of primary alcohol was carried out using acetic acid and saturated KMnO4 solution. The appearance of a brownish-red colour on vigorous shaking indicates the presence of primary alcohol.

3.2 Fuel Properties

Martin Pensky Apparatus was used to determine the fuel properties of the synthesized bioethanol. Figure 2 depicts



Figure 2. Martin Pensky apparatus used for determining flash point and fire point.

the Martin Pensky Apparatus used for the determination of Kinematic viscosity, Flash point and fire point of the Bioethanol blend B10 to B100. The results obtained are tabulated in Table 2.

3.3 Pollutant Emission Estimation

3.3.1 Carbon Monoxide (CO)

Figure 3 shows the percentage of CO emission for different Petrol and bioethanol blends. As the temperature of the combustion chamber increased the CO emission also increased. It can be concluded from Figure 3 that, in general, the CO emission of Ethanol Petrol Engine and its blends is competitively lesser to Petrol Engine. The least CO emission is found in B30. This is due to the increase in oxygen concentration in the fuel as the ethanol content increases which enhances the combustion characteristics of the fuel blend.

Table 2. Fuel properties of bioethanol blend.

Bioethanol Blend	Flash Point ˚C	Fire Point ˚C	Kinematic viscosity at 40˚C	Dynamic viscosity at 40˚C
B100	134.1	197.1	6.74	5.63
B30	96.6	157.9	3.93	3.10
B20	95.1	156.3	3.58	2.82
B10	86.5	150.9	3.57	2.80

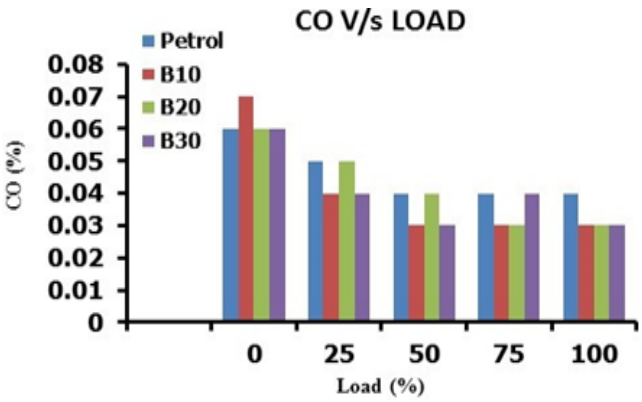


Figure 3. CO (carbon monoxide) versus load.

3.3.2 Hydrocarbons

Figure 4 shows the emission of hydrocarbons in different bioethanol and petrol blends. The hydrocarbon emission is high for only petrol and the same decreased with the addition of bioethanol. For all the samples hydrocarbon emission was found to be less at 100% load and among all the samples B30 showed the least hydrocarbon emission.

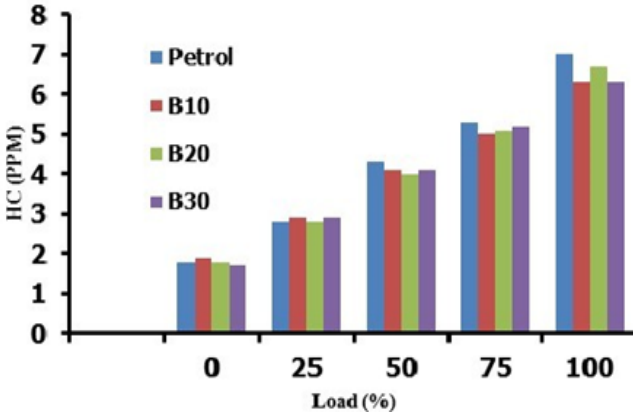


Figure 4. Hydrocarbon emission versus applied load.

4.0 Conclusions

Low-cost second-generation bioethanol was produced using lignocellulose wastes of *Artocarpus heterophyllus*. Qualitative analysis for sugar is done using various methods like the iodine test and Benedict's test. Quantitative analysis for sugar content estimation is done using the DNSA method. The sample obtained after pretreatment with 3% sulfuric acid was found to have higher sugar content. The produced bioethanol was tested for its efficiency in a four-stroke single-cylinder petrol engine test rig. After successful testing, it is evident that the ethanol blended with petrol in 30% proportion is found to be more efficient than pure petrol. The concentration of unburnt hydrocarbons and emitted carbon monoxide in petrol ethanol blend was found to be less compared to petrol alone at full engine load. The results obtained indicate, that the use of ethanol along with petrol gives better efficiency and also can contribute to reducing environmental pollution.

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