Value Addition of Woody Biomass (Saw Dust) to Bio ethanol

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Abstract

This study investigates the potential to valorise woody biomass (saw dust) to make bio ethanol as a source of green and sustainable energy at the same time managing waste from the timber industry. A sample of 300 g of the saw dust was shredded and then pre-treated with steam at 105 ◦C for 10 minutes. This was followed by 1-3 v/v% H_2SO_4 acid hydrolysis at 90 ◦C for 30 minutes to obtain glucose. The glucose was then fermented at 35 ◦C, for 48 hours, pH of 5-6 with 2-6 v/wt. % yeast as biocatalyst. % being shaken 100-200 rpm. Optimal glucose concentration of 160g/300g and bio ethanol concentration of 60g/300g of saw dust were achieved for 3 v/v% H_2SO_4; 6wt. % yeast concentration with 200 rpm as the stirring rate.

Keywords: Bio ethanol, fermentation, glucose, saw dust

1. Introduction

The energy demand is increasing every day and fossil fuels face a potential depletion. There is therefore a need to look for alternatives that are renewable and eco-friendly hence the drive for the uptake of bio fuels as first and second generation fuels (Balat et al., 2008). Biofuels from lignocellulose materials have taken the centre stage as the source of bio ethanol, a source of renewable energy. Lignocellulose materials are processed to bio ethanol using key processes which include pre-treatment, hydrolysis, fermentation and distillation as a product separation technique (Vallejos Vallejos et al., 2017). The production of bio ethanol from lignocellulose material involves thermal, chemical and bio chemical processes that yield a high quality product (Vallejos Vallejos et al., 2017). The bio ethanol production process is shown in Figure 1.

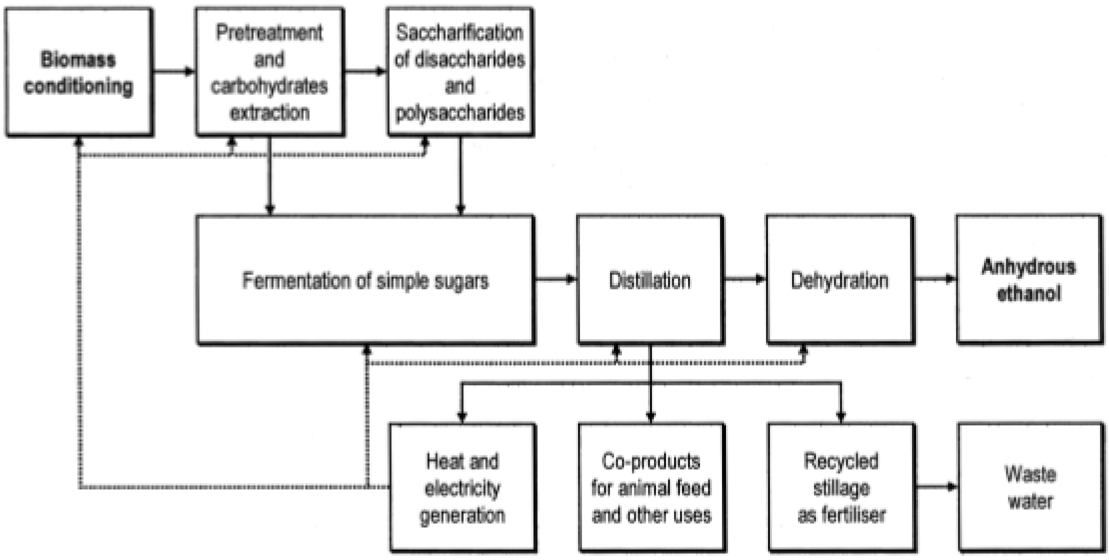

Figure 1: Bio ethanol production process from biomass (Gnansounou and Dauriat, 2005)

Bio ethanol is a clear liquid alcohol that can be used to manufacture blended petrol or diesel or be used in its own right as a fuel. Bio ethanol is produced from lignocellulose material as indicated in Equation 1.

$$C_6H_{12}O_6 \rightarrow \ 2C_2H_5OH + 2CO_2 \ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

Bio ethanol has been produced from various lignocellulose materials including cornstover, sugar cane bagasse and recently from saw dust, a raw material that is abundant in Southern Africa due to its timber industry (Alvaria et al., 2010; Nwakaire et al., 2013). The utilization of saw dust to bio ethanol provides an opportunity for waste management at the same time mitigating the greenhouse gases emissions to the environment during the saw dust degradation. Adoption of bio ethanol production at large scale in the Sub Sahara Africa will also promote infrastructure development.

2. Materials and methods

Saw dust samples were collected from a local timber milling plant and were washed to remove any dirt. The saw dust particles were oven dried to reduce moisture content and then shredded to an average particle size of 0.1 mm. The saw dust was characterized on a dry basis using a methodology in accordance to the National Renewable Energy Laboratory Analytical Procedures for total solids, moisture content, carbohydrates, and lignin and ash content composition.

A 300g sample of the saw dust was first steam pre-treated at 105 ◦C for 10 minutes to expose the saw dust components for both hydrolysis and fermentation. This was then followed by acid hydrolysis using H_2SO_4 and heating at 90 ◦C for 30 minutes in the ratio 2: 1 in favour of the acid. The acid concentration was varied between 1-3 v/v% to quantify the effect of acid hydrolysis on the glucose generation. The sample was put under reflux for 2 hours at 120 ◦C. The cellulose in the saw dust is converted to glucose in accordance to Equation 2.

$$Cellulose \rightarrow Cello\ oligosaccharides\ \rightarrow Glucose \ldots\ldots\ldots\ldots\ldots..(2)$$

The glucose concentration that was present in the hydrolysate was determined using the Dintrosalicylic (DNSA) reagent and a 340-600 nm spectrophotometer. The DNSA reagent was prepared by adding 20 mL of 2N NaOH to 1g DNSA which was mixed with NaK solution in the ratio 1:1 with distilled water to make 100 mL. A sample of

2 mL of the DNSA reagent was heated for 5 minutes and then cooled in order to obtain the absorbance of the sample using the spectrophotometer at 540 nm wavelength.

The hydrolysate was then subjected to fermentation with yeast as the fermentation media at 35 ◦C for 48 hours at pH 5-6 in a shaker with agitation being varied at 150-200 rpm. The yeast (*Saccharomyces cerevisiae*) concentration was varied between 2-6 v/wt. % so as to determine the impact of yeast as a bio catalyst. The pH adjustment was lone using lime. After the 48 hours, the lignin was separated using a filter paper. The filtrate was then distilled for 45 minutes at 78 ◦C. The density of the distillate was compared to the ethanol-water table to obtain the purity of the saw dust derived bio ethanol.

3. Results and discussion

3.1 Characterization of the saw dust

The characterization of the woody biomass is shown in Table 1. The sawdust had high carbohydrates and lignin concentration which are very useful ingredients in bio ethanol production.

Table 1. Characterization of the saw dust.

Component	Value
Total carbohydrates	50.5±2.5
Total lignin	36.3±1.8
Ash content	0.6±0.1
Moisture content	12±0.6

3.2 Glucose production at various acid concentrations

The amount of glucose produced increased with increase in time with the highest amount of glucose of 160 g/ 300g dry material being achieved at 48 hours at a H_2SO_4 concentration of 3 v/wt. % (Figure 2). This was attributed to the fact that the pre-treatment and the acid hydrolysis with H_2SO_4 made the extractible sugars more available especially at higher concentrations (Thimang et al., 2015). The pre-treatment of the saw dust was very critical as it enhanced the accessibility of cellulose which in turn resulted in the high yield of the glucose.

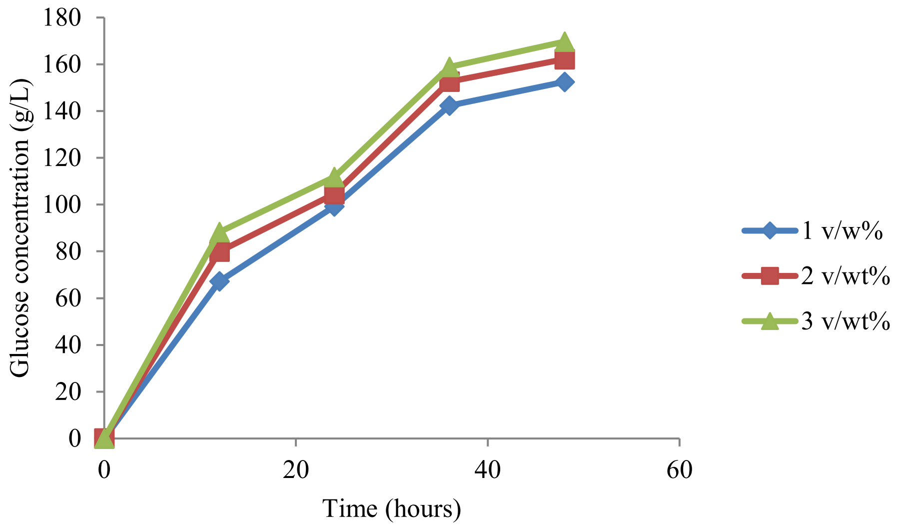

Figure 2: Glucose production from saw dust from hydrolysate at various H2SO4 concentrations

3.3 Bio ethanol production at various catalyst concentrations

The amount of bio ethanol produced from the saw dust increased with increase in time with a maximum of about 60 g/300g dry material being achieved at 48 hours (Figure 3). The amount of bio ethanol produced followed the same trend as that of the amount of glucose that available for fermentation from hydrolysis. The bio ethanol had a purity of 99.1%. The bio ethanol from the saw dust can be used as fuel on vehicles, lowering the dependency on fossil fuels providing an alternative source from an abundant material.

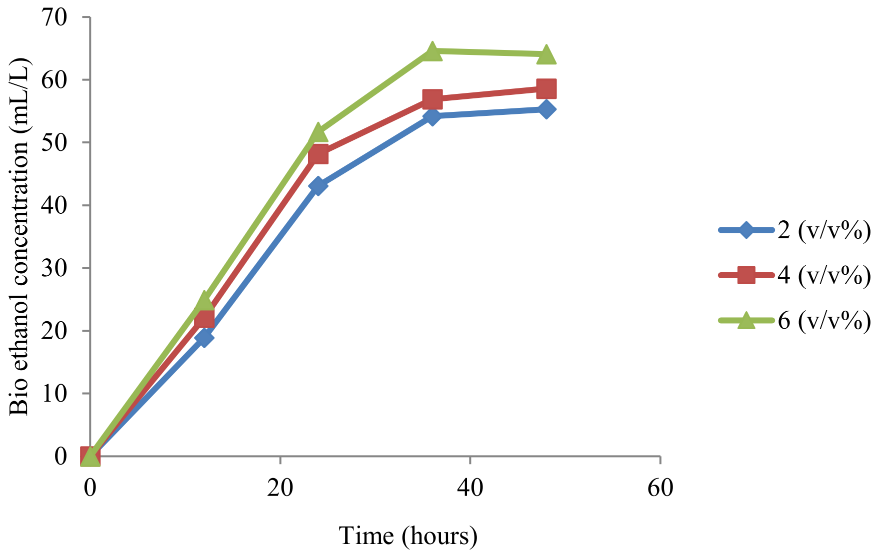

Figure 3: Bio ethanol production from saw dust at various yeast concentrations

3.4 Effect of agitation on bio ethanol production

The amount of bio ethanol obtained from the saw dust was highest at 200 rpm for constant yeast concentration of 6 (v/wt. %) with a highest quantity of 60g/300g being achieved (Figure 4). The agitation in the shaker promoted the enhanced contact between the glucose and the yeast cells resulting in high bio ethanol concentration.

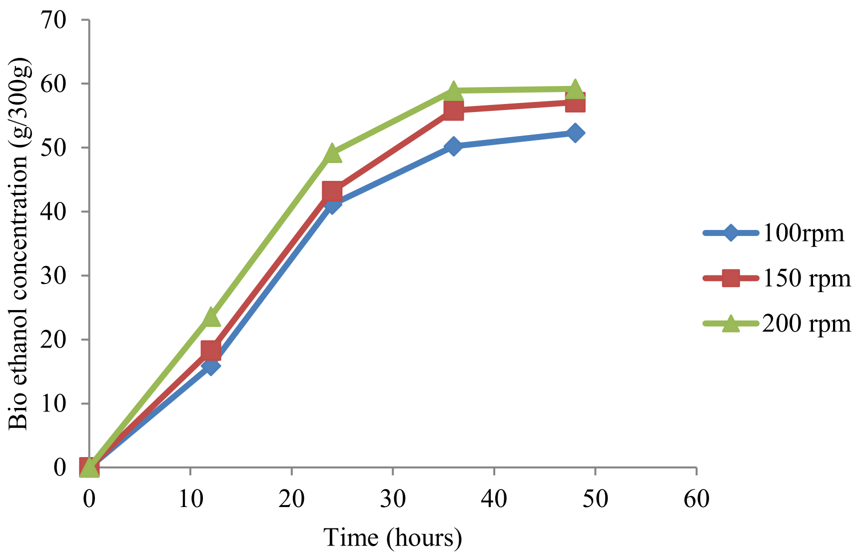

Figure 4: Bio ethanol concentration at varying stirring rates

4. Conclusion

Saw dust (woody biomass) provides a good raw material for bio ethanol production. Retention time of 48 hours was ideal for high glucose yield of 160g/300g of saw dust and bio ethanol yield of 60g/300g of saw dust. Optimal conditions for high glucose and bio ethanol concentration were achieved at H_2SO_4 concentration of 3 v/wt. %, yeast concentration of 6 v/wt.% at an agitation of 200rpm.

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Biographies

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