Hydrolysis of Cellulose from Bamboo with Biology Process Using Enzyme

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Hydrolysis is a process to breakdown cellulose into glucose. Bamboo is one of the materials that have sufficiently high cellulose content. The bamboos used in the hydrolysis process those that do not contain lignin and pentose that previously performed pretreatment and delignification process. The purpose of this research is to produce glucose as a feedstock for bioethanol, knowing pentose and impurities remaining in bamboo solution. Therefore it needs to be studied in the future, what is the best process to use, biology or chemical process using acids that can optimize glucose production. The enzyme treatment is also very important because the enzyme has an optimal condition, temperature, and pH and when the enzyme is in optimal condition, it can increase the enzyme’s work rate. Variables maintained in hydrolysis process were temperature of 45 °C, bamboo solution 500 ml, and stirring speed in control 200 rpm. The free variables were enzyme’s weights of 1, 3, 5, 7, 9 gr and hydrolysis time 30, 60, 90, 110, 130 minutes. Results from the hydrolysis process can produce glucose level of 23.6% from the bamboo’s weight. The result from hydrolysis process is glucose and the next treatment is fermentation to obtain bioethanol products.

Keywords: Bamboo, Cellulose, Enzyme, Hydrolysis.

1. INTRODUCTION

Biomass from plants has been declared as an alternative raw material for gasoline fuel substitution in the form of bioethanol. Bioethanol obtained from biomass and bioenergy crops has been proclaimed as one of the feasible alternatives as gasoline fuel.1

The technology for lignocellulose ethanol production is primarily dependent on initial treatment, chemical or enzymatic hydrolysis, fermentation and distillation. A proper treatment strategy is required so that the enzyme hydrolysis of ligno-cellulosic biomass to be efficient, because lignin prevents the saccharification process. There were numerous approaches for pretreatment process before such as acid or alkali pretreatment, pretreatment with hydrogen peroxide, steam explosion, liquid hot water, ammonia fiber expansion pretreatment, NaCl, and biological pretreatment.2

The research is conducted to evaluate acid pretreatment from NaOH paper waste as material for production, optimized sulfuric acid hydrolysis.3 Chemical pretreatment of ligno-cellulosic biomass with H2SO4 and H3PO4 acids are widely used since they are relatively cheap and efficient in the hydrolysis of lignocellulose, though the latter gives a milder effect and is more benign to the environment. HCl is more volatile and easier to recover and attacks biomass better than H2SO4,4 similarly, nitric acid (HNO3) process good cellulose to sugar conversion rates.5 However, both acids are expensive compared to H2SO4. Pretreatment of lignocellulose has received considerable research globally due to its effluence on the technical, economic, environmental and sustainability of cellulose ethanol production. This paper reviews already known and emerging chemical pretreatment methods, the combination of chemical pretreatment with other methods to improve carbohydrate preservation reduce formation to degradation product, achieve high sugar yield at mild reaction conditions, reduce solvent loads and enzyme dose, and reduce waste generation.6

Pretreatment process used to process the Cellulose into glucose, which is derived from cellulose that lingo-cellulosic residues, sugarcane, and bagasse.7 Processing technology of lignin on the biomass required pretreatment technology for separating: cellulose, hemicellulose, and lignin.8

Pretreatment for hydrogen and bioethanol production from olive oil waste products was ethanol yield 5.4% treatment with 1.75 w/v H2SO4 and heated it at 140 °C for 10 min.9 Pretreatment followed with simultaneous scarification and fermentation on biocconversion of microcrystalline cellulose.10 A sustainable feedstock bioethanol production, cellulose hydrolysis was microwave irradiate using hydrochloric acid as catalyst, fermentation with...
Bioethanol from paper fiber residue using NaOH diluted in

Elements contained in the lignocellulosic biomass of the plants usually used lignocellulose biomass that is potential for bioethanol production globally. Agriculture (soft wood), forestry (hardwood), and industrial waste are a major lignocellulose biomass for bioethanol production. The lingo-cellulosic biomass is one of the potential main sources for economic bioethanol production globally. Agricultural, forestry (soft and hardwoods) and industrial wastes are the major ligno-cellulose biomasses. The lingo-cellulosic biomass for bioethanol production was developed using inhibitors-tolerant Saccharomyces Cerevisiae, more than 4% (w/w) ethanol concentration was achieved, which corresponded to 72.3% theoretical yield of ethanol. Bioethanol production using sodium hydroxide pretreated sweet sorghum bagasse without washing, ethanol theoretical yield from 44.06 ± 0.93% to 65.14 ± 0.91%. The bioethanol production from lignocellulose biomass uses process pretreatment, hydrolysis, fermentation, and recovery of ethanol. The research conducted by Ref. [17], about bioethanol production from agricultural waste using PROFER pretreatment method. The purpose of dilute acid pretreatment is to eliminate hemicelluloses and to restore the sugar component. This technique is long recognized as a crucial step to remove hemicellulosic fraction and an economic way to convert cellulosic biomass to ethanol biochemically. The research conducted by Ref. [19] about ethanol production from sago pith waste (SPW) using microwave hydrothermal hydrolysis catalyzed by carbon dioxide, resulted in higher energy saving compared to previous techniques in the absence of enzymes, acid or base catalyst.

Bioethanol from paper fiber residue using NaOH diluted in the fermentation process with Penicillium Chrysogenum, and Saccharomyces Cerevisiae. The fermentability of the hydrolysate decreased strongly for hydrolysis produced at a temperature higher than 50 °C, the ethanol concentration of monosaccharide hydrolysis was found to be 34.06 g/L and ethanol yield was 0.097 g/g. Bioethanol production from lignocellulosic biomass involves different step such as pretreatment, hydrolysis, fermentation and ethanol recovery. The technology for lignocellulose ethanol production is primarily dependent on initial treatment, chemical or enzymatic hydrolysis, fermentation and distillation. A proper treatment strategy is required so that the enzyme hydrolysis of ligno-cellulosic biomass to be efficient, because lignin prevents the saccharification process. There were numerous approaches for pretreatment process before such as acid or alkali pretreatment, pretreatment with hydrogen peroxide, steam explosion, liquid hot water, ammonia fiber expansion pretreatment, NaCl, and biological pretreatment.

Cellulosic or second generation (SG) bioethanol is produced from lingo-cellulosic biomass (LB) in three main steps: pretreatment, hydrolysis, and fermentation. Pretreatment involves the use of physical processes, chemical methods, physicochemical processes, biological methods, and several combinations thereof to fractionate the lignocellulose into its components. It results in the disruption of lignin seal to increase enzyme access to holocellulose, reduction of cellulose crystallinity, and increase the surface area and porosity of pretreated substrates, resulting in increased hydrolysis rate. In hydrolysis, cellulose and hemicelluloses are broken down into monomeric sugars via the addition of acids or enzymes such as cellulose. Enzymatic hydrolysis offers advantages over acids such as low energy consumption due to the mild process requirement, high sugar yield, and no unwanted wastes. Enzymatic hydrolysis of cellulose affected by properties of the substrate such as porosity, cellulose fiber crystallinity, and degree of polymerization, as well as lignin and hemicellulose content, optimum mixing, substrate and end-product concentration, enzyme activity, reaction conditions such as pH and temperature. Numerical and experimental bioethanol production from liquid waste of rice flour with process hydrolysis, fermentation and batch distillation with batch process. From the previous research, it was known that cellulose from bamboo resulted in good cellulose. The aim of this research was to search material bamboo from Indonesia with pretreatment process, and delignification process to gain cellulose product with a high level of cellulose. The originality of this research was the second generation that was bamboo, by using two processes (pretreatment and delignification) simultaneously, technical cellulose production with combination acid (H2SO4) and base (NaOH) level of 40–50 (%), degradation lignin levels 20–25 (%), and pentosan levels as the substitution material of glucose.

2. METHODOLOGY

From the result of laboratory analysis, it was known that bamboo forming elements were composition: cellulose 42.4%–53.6%, lignin 19.8%–16.6%, pentosan 3.47%–1.24%, extractive substances 4.5%–9.9%, water 15%–20%, ash 1.24%–3.47%, and SiO2 0.1%–1.78%. The cutting of bamboo with approximately 100 mesh size was done in order to obtain the high level of cellulose and low level of lignin during pretreatment process by H2SO4, and delignification process by NaOH. The quality of cellulose was determined by various influencing parameter such as the ratio weight bamboo with volume H2SO4, ratio weight bamboo with volume NaOH, temperature, and delignification time.

3. EXPERIMENTAL RESULT

The quality analysis of raw materials and cellulose product was done by laboratory analysis. The analysis was conducted on the instrumentation and gravimetric analysis in Figure 1 by using Atomic Adsorbent Solvent (AAS) and Spectrophotometer, which analyzed items were concentration: cellulose, lignin, pentosan, extractive substances, water, ash, and SiO2.

Fig. 1. Cellulose production flow used pretreatment process, delignification process, and hydrolysis process.
The procedure of pretreatment and delignification process: Bamboo is dried under the Sun, weight bamboo is 50–250 grams, as many as 3-liter aqua dest mixed with 200 ml of H₂SO₄ 2 N, then inserted into the tool extraction, in the heater with temperature 25–125 °C, and extraction time is 30–150 minutes. In this process, the lignin will separate from bamboo with filtering tools, so a layer of cellulose will be processed hydrolysis with free lignin. The procedure of extraction process: Sample of weight bamboo 50 grams, that has become powder added 3-liter of aqua dest, and NaOH 2 N with the variation of concentration of 2–10 (%v/v), heated at a temperature 25–125 °C, then filtered and washed with water until neutral pH.

The procedure of hydrolysis process: the fibers obtained from the process of pretreatment is taken as much as 50–250 grams and added water 800 ml is then inserted into the tool hydrolysis, the process of hydrolysis using free variable volume enzyme of cellulose hydrolysis and time. So do the experiment as much as 25 times with a variable that has been defined earlier. The temperature maintained at 45 °C, because in the enzyme of cellulose can work optimally at temperatures around 40–50 °C and stirring round of speed 200 rpm. After it is filtered and the filtrate is obtained from the solution of bamboo has done its hydrolysis, the filtrate obtained were tested to find out how glucose content contained therein.

In base extraction, sulfate acid was commonly used in a certain level. Extraction was usually done in a special tank made of stainless steel or copper pipe connected to the heating ducts and exhaust pipes in order to regulate the air pressure. The cellulose content of bulrush could be converted into glucose by concentrated base extraction process with certain concentration.

Figure 1 showed extraction process was done by the various weight of bulrush: 50, 100, 150, 200, and 250 (grams) by the addition sulfate acid. After the extraction process was finished thus the solid and filtrate were obtained. The filtrate will be processed by the fermentation process to obtain ethanol concentration and solids can be used as compost. The effect of pH was essential in the fermentation process so filtrate must be measured for pH in the minimum level of 3.5 until the maximum level of 4.5. The optimum cellulose contains as 100 °C and 250 grams bamboo is 49%.

Figure 2 showed extraction process was done by the various weight of bulrush: 50, 100, 150, 200, and 250 (grams) by the addition sulfate acid. After the extraction process was finished thus the solid and filtrate were obtained. The constant lignin contains as 100–125 °C and some bamboo is 24.7%.

Figure 3 showed extraction process was done by the various weight of bulrush: 50, 100, 150, 200, and 250 (grams) by the addition sulfate acid. After the extraction process was finished thus the solid and filtrate were obtained. The constant lignin contains as 90 minute and 150 grams bamboo is 49%.

Figure 4 showed extraction process was done by the various weight of bulrush: 50, 100, 150, 200, and 250 (grams) by the addition sulfate acid. After the extraction process was finished thus the solid and filtrate were obtained. The constant lignin contains as 90–120 (minute) and some bamboo is 24.7%.
4. CONCLUSIONS

Based on the aim of research in reviewing of process pretreatment, delignification and extraction, and also searching for alternative material of cellulose product. The optimum cellulose contains in the delignification process was 49%, and decreased lignin contain is 24.7%, at temperature 100 °C and 90–120 (minute). The optimum glucose contain in the hydrolysis process was 9%, at temperature 45 °C, stirring round of speed 200 rpm, and 25 minutes.

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References and Notes


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