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Kinetic Study Of Hydrolysis Of Coconut Fiber Into Glucose

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Abstract. Kinetic study of hydrolysis of coconut fiber into glucose has been done. The aim of this research was to study of the effect of time and temperature to the glucose as the result of the conversion of coconut fiber. The various temperature of the hydrolysis process were 30 ^oC, 48 ^oC, 72 ^oC and 95 ^oC and the various time of the hydrolysis process were 0, 15, 30, 60, 120, 180, 240, 300 minutes. A quantitative analysis was done by measured the concentration of the glucose as the result of the conversion of coconut fiber. The result showed that the rate constant from the various temperature were 3.10^{-4} $minute^{-1}$; 8.10^{-4} $minutees^{-1}$; 84.10^{-4} $minute^{-1}$, and 205.10^{-4} $minute^{-1}$, and the energy activation was 7,69. 103 kJ/mol.

INTRODUCTION

The utilization of fossil fuels as an energy source can cause emission sources, namely CO_2. To overcome this problem, many people are looking for alternative energy sources to replace fossil energy sources [1]. One of alternative energy resources is biomass. Biomass is biodegradable materials, waste and residues from plants and it is a renewable raw material, cheap and widely available on earth [2].

Lignocelluloses component consists of cellulose (40-50%), hemicellulose (25-35%) and lignin (15-20%) [1,3]. Cellulose is a biopolymer that is widely available in nature and has been used as an alternative energy source [4]. Cellulose consist of glucose units that is connected β-1,4-glycosidic bonds. Damage of the β-1,4-glycosidic bonds by acids produces glucose or oligosaccharides [5]. Conversion of cellulose to glucose can be achieved by acid and enzyme as catalyst in hydrolysis process [6]. The hydrolysis of cellulose using acid is a complex heterogeneous reaction (**Fig 1**) [7].

Based on **Fig 1** shows that a proton from the acid that interact quickly with oxygen glycosides that connects the two units of glucose (I), forming a conjugate acid (II). Termination of the C-O bond and the destruction of the conjugate acid produces cyclic carbocation intermediates (III). Protonation can also occur in the ring oxygen (II'), produces carbonium cationic ring opening and non-cyclic (III'), there is no certainty the carbocation are most likely to form. The second possible modification occurs with the largest possible protonated to the cation cyclic. Carbonium cations eventually began around you add the water molecules quickly form a stable end result and releases the proton [8].

The method of chemical Hydrolysis is the method that low cost and fast [9]. The factor that might have impact on the cellulose into glucose concentration are temperature, acid concentration, and duration of time [6]. So, the aim of this research was to study of the effect of time and temperature to the glucose as the result of the conversion of coconut fiber.

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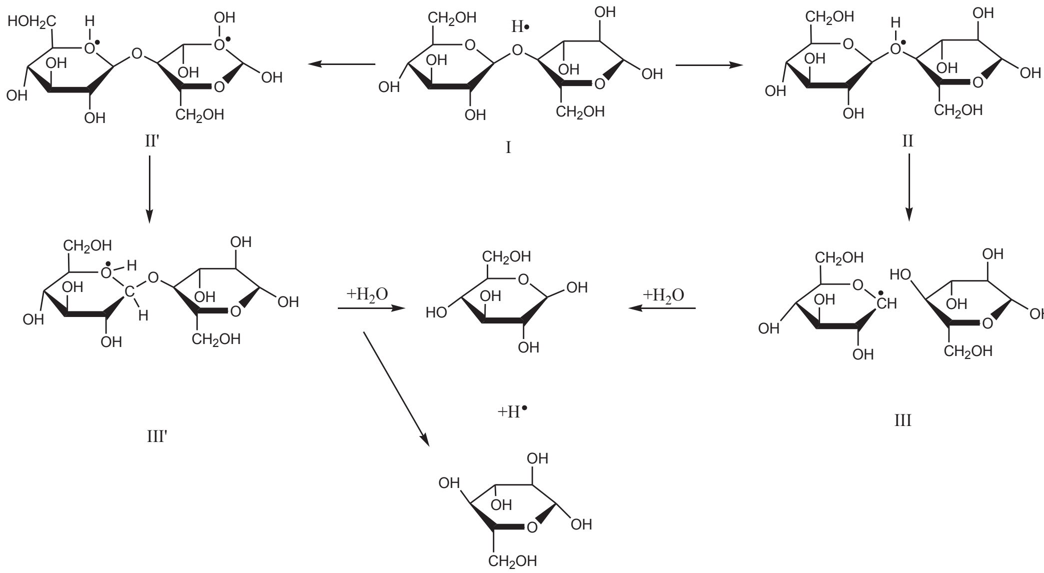

FIGURE 1. Mechanism of acid catalyzed hydrolysis of β-1-4 glucan [7]

MATERIAL AND METHODES

Raw material

The raw material used in this experiment was coconut fiber from home industry in Kulonprogo, Yogyakarta, Indonesia. The coconut fiber was dried for eight hours at 110 ^{o}C.

Acid hydrolysis of coconut fiber

30 gram sample was added to 300 ml of H_2SO_4 0.1 N in three neck flask. The samples were hydrolysed for 5 hours at 100 ^{o}C, at 0, 15, 30, 60, 120, 240 and 300 minutes, samples were witdrawn to determne the glucose concentration. The concentration of glucose of the filtrate was measured using the Nelson-Somogyi method [10,11].The same procedure was repeated for 30, 48, 72, and 95 °C. The illustration of the hydrolysis process was shown in Figure 2**.**

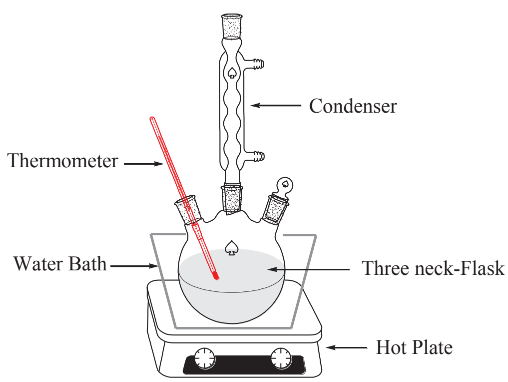

FIGURE 2. Hydrolysis Process

RESULT AND DISCUSSION

The effect of temperature to glucose concentration

Studies on the effect of temperature on the results of the hydrolysis process aims to determine the glucose concentration optimum. The influence of temperature was studied by means of varying the temperature hydrolysis process coconut fiber, and sampling was conducted during a certain time interval from minute 0 to minute 300. The result of the effect of temperature to glucose concentration was presented in **Fig 3.**

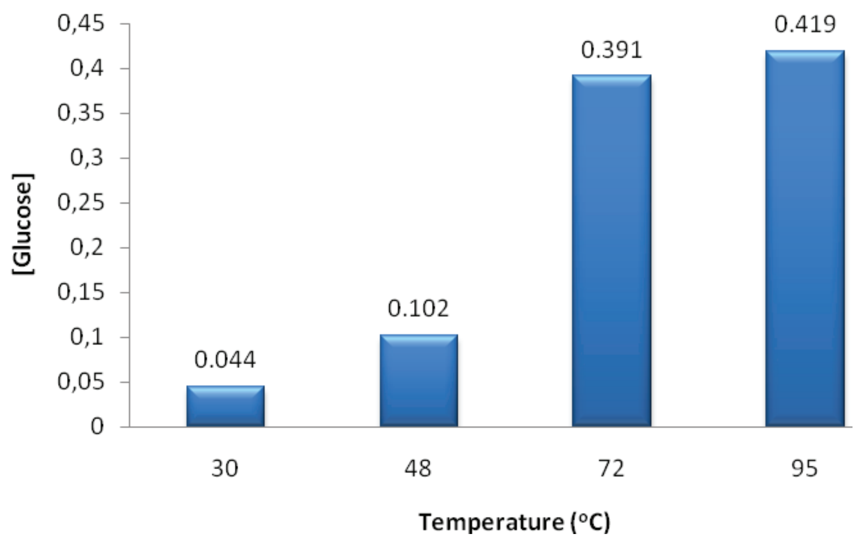

FIGURE 3. The graph of temperure vs glucose concentration

According to **Fig 3.** showed that the more the temperature is raised, the concentration of glucose formed in the hydrolysis process increasingly large. At 30, 48^{o}C, 72^{o}C and 95^{o}C amount of concentration that forms on successive hydrolysis process is 0,045; 0.102; 0.391; and 0.419 mg/mL. This indicates that when the temperature is raised then the process of collision between molecules will be more frequent so that the concentration is formed also increases, in addition to the long chain cellulose molecules contained in it will be easier to cut into glucose monomers.

The effect of time to glucose concentration

The effects of time on the hydrolysis of coconut fiber can be seen in Fig 4. It showed that the longer the time of the hydrolysis of coconut fiber, the conversion of cellulose to glucose tends to increase. Besides, the tendency of molecules to collide each other more widely in line with the length of time hydrolysis. The longer the time the hydrolysis of coconut coir then the reaction rate will be higher. This was seen in the 15th minute in which the glucose concentration increased with the length of time and assumed hydrolysis of cellulose contained in the coconut fiber was also reduced to glucose. In the Fig 4 appeared that the conversion of glucose at minute 120 and 240 have shown a decrease, but at minute 300 glucose concentration increases rises, it indicated that the time for the hydrolysis process has not yet reached stability and still increase the concentration and to obtain conditions the most well needs to be done hidrolsis much longer.

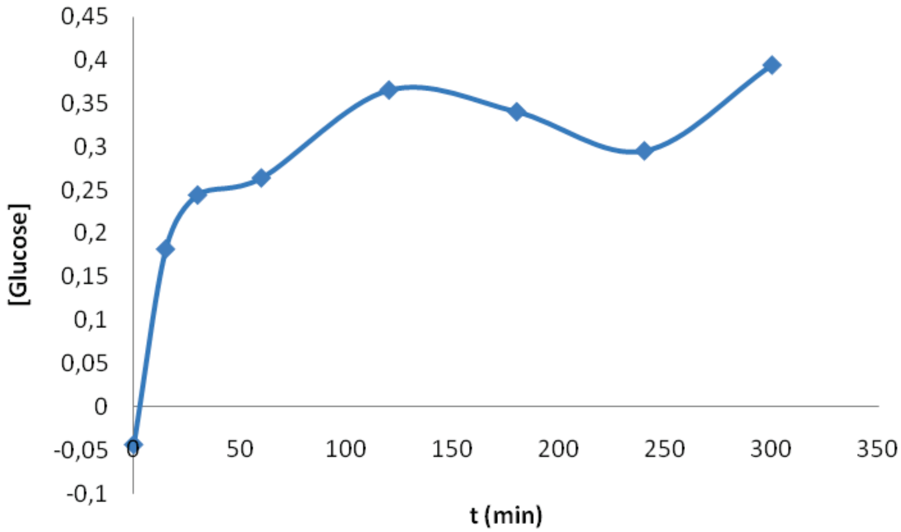

FIGURE 4. The graph of time vs glucose concentration

Determining of the order of the reactant

To determine reaction order there are several ways, namely the integral method, graphical method, the method of initial rates, the fraction of time method and the reaction mechanism [12]. Determination of the order of the reactant of hydrolysis of coconut fiber was done by the graph methode. According to the Fig 4 was used to determine the order of the reactant.

Hydrolysis reaction of coco assumed to follow a first order reaction, because of the large volume of water in the hydrolysis process so the concentration was considered unchanged and can be ignored.

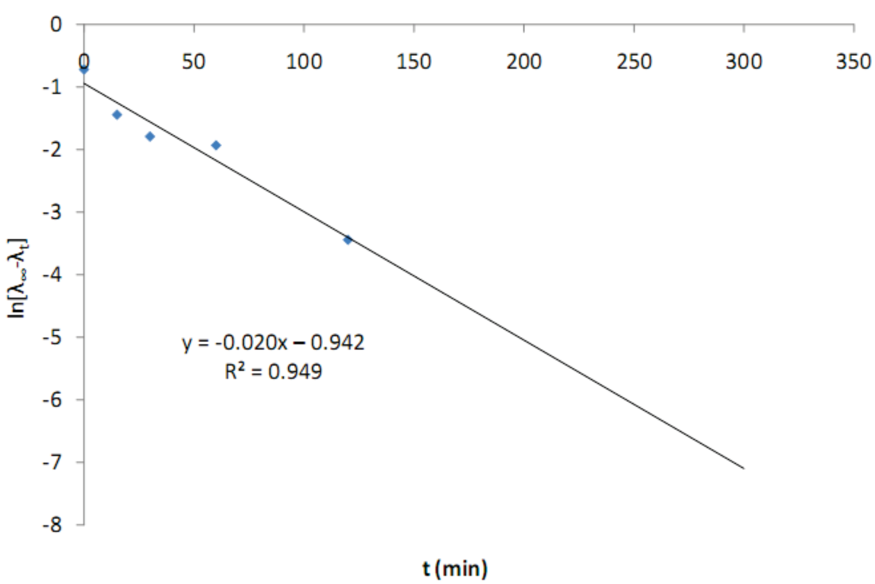

FIGURE 5. The graph of time vs $\ln[\lambda_\infty - \lambda_t]$

Fig 5 appeared that formed then a linear line between ln $[\lambda_\infty - \lambda_t]$ vs t with a value of regression (R^2) was equal to 0.949 or close to 1. Thus, the data hydrolysis process results meet the rules of first order.

Determination of the reaction order based on the level of data consistency that gives the regression value close to 1. Sulistyo and Arifin [13] on the kinetics of the hydrolysis reaction cassava flour with natural zeolite catalyst showed hydrolysis of cassava with natural zeolite catalyst follow pseudo first order reaction against the concentration of starch. Meanwhile Artati and Andik [14] for his work on the hydrolysis of starch banana stated that the reaction order for starch hydrolysis bananas following the first order. That is, from a few studies have been done about hydrolysis to obtain glucose following the first order, and this is no different with the research on the hydrolysis of coconut husk which also produces glucose.

Determining of the rate constant

Chemical reactions is taking place at a rate that is different. No reaction take place quickly and there is a reaction that takes place slowly. To accelerate a reaction is necessary to add a catalyst [12]. The hydrolysis reaction of the coconut fiber is slow, so it necessary to add catalyst for decompotition of cellulose. The catalyst used in this study was sulfuric acid. One reason for the determination of the reaction rate of the hydrolysis process was to find out how fast the reaction was running and also to know how big the resulting conversion. For the hydrolysis process followed first order. The results of the study the hydrolysis of coconut husk with different variations in temperature can be seen in the following (Fig 6):

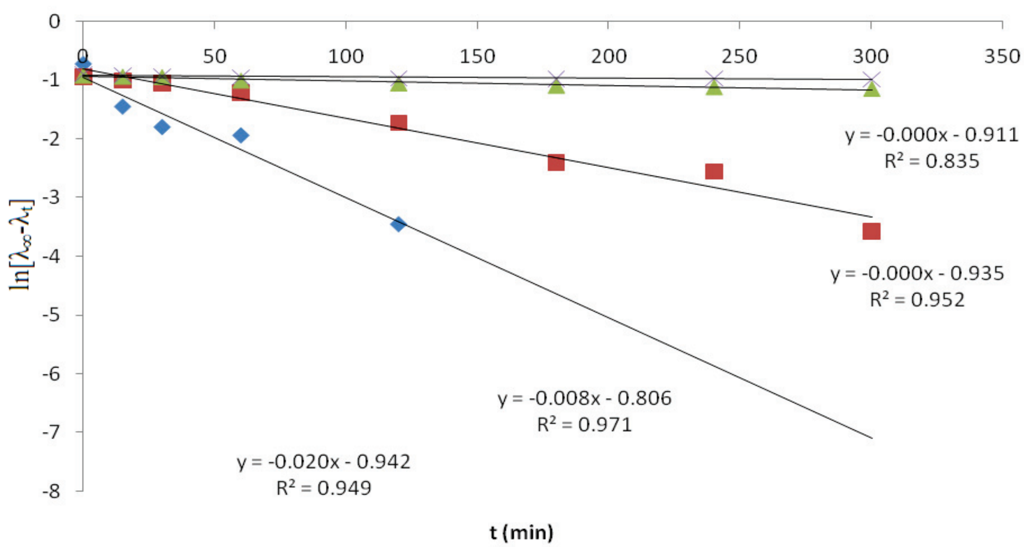

FIGURE 6. The graph of time vs $\ln[\lambda_\infty - \lambda_t]$

The higher the temperature, the higher the hydrolysis reaction rate constant value. Value of the reaction rate constant is the slope of the line on the graph of time to ln[λ_∞-λ_t]. According to Fig 6 showed that the rate constant from the various temperature were 3.10-4 minute^{-1}; 8.10^{-4} minutees^{-1}; 84.10^{-4} minute^{-1}, and 205.10^{-4} minute^{-1}, and the energy activation was 7.69. 10^{3} kj/mol.

Determining the Activation Energy of coconut fiber hydrolysis

Determination of activation energy (E) and collision frequency factor (ko) calculated from the reaction rate constant (k). Arrhenius equation showing the relationship between the temperature of the reaction rate constants [15].

$$k = Ae^{-\frac{E_a}{T}}$$

From the Arrhenius equation, a plot of ln k vs 1/T will have a slope (m) that means energy activation.

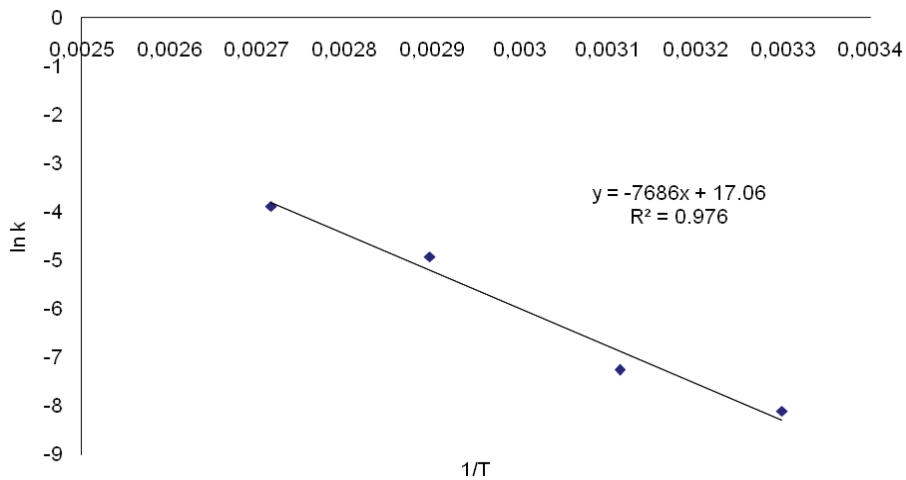

FIGURE 7. The graph of 1/T vs ln k

Fig 7 showed that the slope of the graph 1/T vs Ln k was -7691.5 means that the activation energy was the value of anti-tangent of the graph, so the value of activation energy of hydrolysis process was 7691.5 kJ/mol. The activation energy is influenced by the reaction rate constant, the greater the reaction rate, the smaller the activation energy so that the reaction will be run quickly. The faster the reaction runs the conversion of glucose through the process of hydrolysis of coconut coir will be quickly formed [16].

CONCLUSION

The optimum concentration of glucose of hydrolysis coconut fiber was 0.419104 mg/mL at 95°C. The longer the time of hydrolysis and the higher the temperature hydrolysis of the glucose produced in the hydrolysis process the coco higher. The rate constant at 30 °C, 48°C, 72°C, 95°C are: 3.10^{-4} min^{-1}; 8.10^{-4} min^{-1}; 84.10^{-4} min^{-1}, and 205.10^{-4} min^{-1}. The activation energy (Ea) for the hydrolysis of coconut fiber was 7.69. 103 kJ/mol.

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