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Production of Glucose from Lignocellulosic under Extremely Low Acid and High Temperature in Batch Process, Auto-hydrolysis Approach

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Abstract: In the present investigation production of glucose was achieved in batch reactors from hydrolysis of lignocellulose under extremely low acid (ELA) and high temperature condition by pretreating the sawdust by Auto-hydrolysis *ab initio*. The maximum glucose yield obtained was 70% for the pretreated sawdust at 210°C in the 18th minute of the experiment. This value is 1.4 times maximum glucose obtained from the untreated sawdust under the same condition. The glucose yield gradually decreases after the 20 min of reaction due to its decomposition.

Key words: Glucose, lignocellulosics, auto-hydrolysis, kinetics, cellulose hydrolysis

INTRODUCTION

Production of glucose from biomass origin is a common process of saccharification employed in the industries. There have been numerous literatures on hydrolysis of cellulose and lignocellulose[1-6] reported acid and enzymatic hydrolytic process of sawdust where the kinetic were studied. Badmus[7] produced glucose from palm tree trunk via acid hydrolysis using auto hydrolysis prior to the acid hydrolysis obtaining 70% glucose yield at 2.0% Sulphuric acid. Jeffries and Lee[8] also reported auto-hydrolysis (steam explosion) as an effective pretreatment method for lignocellulosic materials for hydrolysis. In fact, Boussaid *et al.*[1] reported an increasing glucose concentration in the hydrolysate as the severity of stem explosion increases.

Recently, effort has been geared towards achieving hydrolysis of cellulosic materials under very extremely low acid (<0.1%) and high temperature, thereby obtaining improved yield of glucose[9]. The extremely low acid (ELA) condition is not normally employed in the convectional acid hydrolysis process, the corrosion characteristics of ELA are very close to a neutral aqueous reaction, thus standard grade stainless steel equipment can be used instead of high nickel alloy. ELA also gives a significant cost advantage in the equipment. With ELA technique, saccharification of lignocellulose can favorably compete with enzymatic hydrolysis in the overall process economics. The process of using ELA could be regarded has being environmental friendly because it has a minimal environmental effect. Recent findings have proven that yields in the region of 61% are attainable with pure cellulose hydrolysis[9] under the ELA conditions using batch reactor. Also Ojumu *et al.*[6] reported 210 and 220°C as suitable reaction temperature for ELA.

The present study investigates the effect of auto hydrolysis pretreatment method on glucose production from sawdust subjected to hydrolysis under ELA and high temperature conditions and provides kinetic data on the reactions taking place under this condition.

MATERIALS AND METHODS

The sawdust was obtained from sawmill around Obafemi Awolowo University (OAU) vicinity in Ile-Ife town, it was derived from the tree *Triplochiton scleroxylon*. It was milled to pass through a 12 mesh screen (1.44 mm) and this was used as the standard substrate. The composition of *T. scleroxylon* was 69.5–80% cellulose and hemicellulose and 25-30% lignin[10].

Auto-hydrolysis procedure: Kedjahl flask was filled with water to about ¼ volume and heated steadily at about 250°C to obtain super-heated steam. The superheated steam was injected through a glass tubing into a round bottom flask containing about 5 g wood samples for 60 min. Care must be taken to avoid explosion by using plastic cork with two opening for glass tubing, the other opening vents the system of pressure build-up.

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Batch experiment: The batch reactor experiments carried out has been described in details elsewhere[6], except that the reaction temperature of 210 and 220°C were used for the experiment in this case.

Analytical methods: The sugars were determined using High performance liquid chromatograph using Bio-Rad Aminex HPX-87P column[6,9]. A refractive index detector was used. The compositional analysis of the solid biomass samples was carried out using the standard method recommended by Vinzant *et al.*[11]. The sugars in the liquid sample were determined after being subject to a secondary hydrolysis as prescribed by Kim *et al.*[9] and Ojumu *et al.*[6].

RESULTS AND DISCUSSION

Interesting results have been obtained using auto hydrolysis pretreatment for cellulose and lignocellulose hydrolysis[1,7] and also it ELA condition[6,9]. Figure 1 summarizes progress of the reaction in the experiment conducted for the lignocellulosic sample (sawdust)-pretreated by auto-hydrolysis by using 0.07 wt.% Sulphuric acid at temperatures of 210 and 220°C.

The results are expressed in term of the percentages of glucan remaining in solid and the glucose released in the liquid. The maximum yield of glucose obtained from the auto-hydrolyzed sawdust was about 70% at 210°C in 18 min of the experiment while the maximum glucose yield from the untreated sawdust, even though it follows the same trend, was much lower at the same condition (~52%) (Fig. 1). Kim *et al.*[9] obtained a maximum (61%) at the 16 min.

The glucose yield was about 1.4 times of that obtained from untreated sawdust. This is a unique property of auto hydrolysis as reported in our earlier work[6], the process of auto hydrolysis weakens the bonds in the lignocellulosics, thereby exposing these bonds

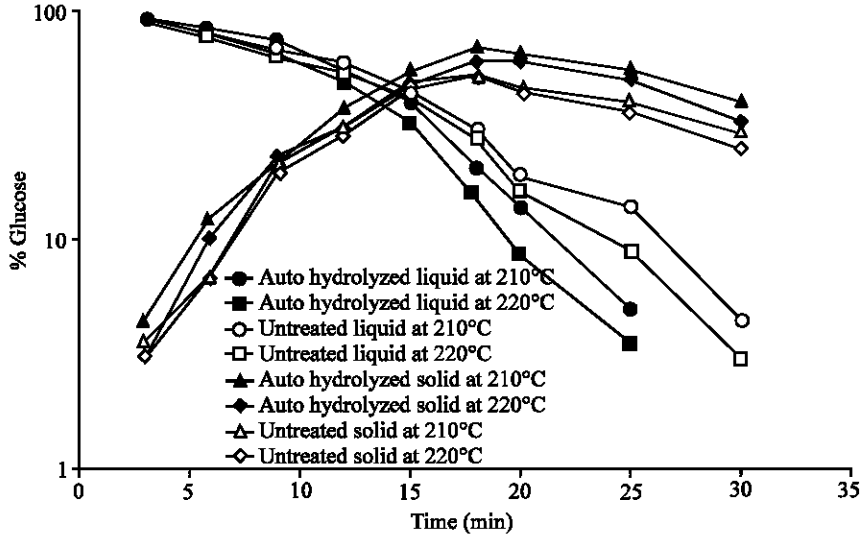

Fig. 1: Semilog plot of glucose yield in batch reaction of sawdust

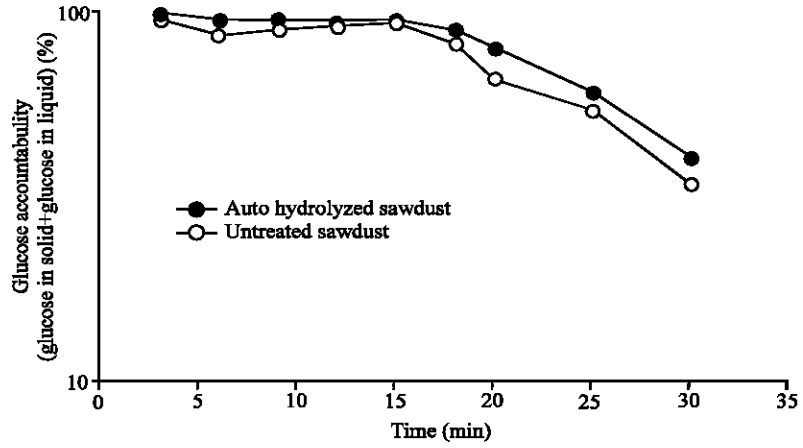

Fig. 2: Semilog plot of glucose accountability for the substrate at 210°C

for ELA penetration, this enhances the hydrolysis reaction as evident by the glucose yield obtained. This was supported by the report of Boussaid *et al.*[1] and Badmus[7]. An increase in yield of glucose was reported by Boussaid *et al.*[1] as the severity of auto-hydrolysis increases from 175-215°C.

After the 20th min. of the reaction the glucose yield decreases steadily with time. Although this was also observed in our previous work[6] and those of others[2,9], the plot of total glucose (Fig. 2) in the whole system confirmed that considerable amount of the glucose was lost after the 20th min. The total glucose of the system was determined by adopting the method of Kim *et al.*[9]. The explanation was that the released glucose decompose to furfural and hydroxylmethylfurfural (HMF) and also some of it recondense with remaining cellulose or lignin[2,9]. According to Conner *et al.*[12] the reduction was due to repolymerization of the glucose to give other product.

In conclusion, the purpose of the present study was to improve current methods of lignocellulose hydrolysis for production of glucose by using auto hydrolysis (steam explosion) and a milder acid condition (ELA). The results of our experiments are as follows:

- Condition for conducting this experiment is: Auto hydrolysis at 250°C for 60 min. and Batch reaction at temperature 210°C for 20 min. using 0.07% H_2SO_4
- The maximum yield of glucose produced was 70% at the 18 min.
- The total productivity of glucose in auto hydrolyzed sawdust was about 1.4 times that obtained from untreated sawdust.

These results show that auto hydrolysis pretreatment method can be considered further as one of the potential ways of conversion of lignocellulosics to glucose. But at the same time the given problem demands further more detailed study depending on concrete conditions of realization of the hydrolysis and substrates.

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