

PLATFORM A (PURE AND APPLIED CHEMISTRY)

ACID AND ENZYMATIC HYDROLYSIS OF CELLULOSE FROM WASTE PAPER TO GLUCOSE

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ABSTRACT

This paper studied on the production of glucose, a platform chemical, obtained from the hydrolysis of cellulose in waste paper catalysed either via acid or enzyme. Waste paper was utilized in the study as it was abundance, does not compete with food source, high in cellulose content and low in both hemicellulose and lignin content. The formation of glucose was achieved with the breakage of β -1,4-glycosidic linkages that exist between the oxygen and the carbon atoms, of a pair of glucose unit in a cellulose strand. The glucose concentration in the acid hydrolysis was 0.0168 mol/L representing 76% of cellulose conversion to glucose. The glucose concentration in the enzymatic hydrolysis was 0.0210 mol/L representing 72% of cellulose conversion to glucose. Taking into account on the reaction condition and time, by-product production as well as the toxicity issues, this paper confirms the fact that enzymatic hydrolysis is far more advantageous compared to acid hydrolysis process in the production of glucose from cellulose in waste paper.

INTRODUCTION

It is interesting to note that glucose, a base compound for many high-value goods. Gluconic acid, lactic acid, ethanol, ethylene glycol, sorbitol, and furfural are just a few of the high-value chemicals that may be produced from it. The main driver of the rising interest in the hydrolysis of waste paper into glucose is cellulose, which makes up approximately 50-60% of waste paper's component [1]. Acid hydrolysis of office waste paper [2-3], used paper towel [4] has resulted in high glucose concentration, with the cellulose conversion of 70-100%. However, acid hydrolysis is an outdated technique in which the unreacted acid in the process is typically not recycled; instead, it is only neutralised, creating significant amounts of salt, which makes this procedure problematic from an economic and environmental standpoint [5]. The hydrolysis industry has switched over in recent decades from employing acid to enzyme in the hydrolysis process. Minimal toxicity, low corrosion, no inhibiting by-products, and little environmental harm are all characteristics of enzyme hydrolysis [6]. Enzymatic hydrolysis of used office paper and newspaper [7-8] also has resulted in high glucose concentration, with the cellulose conversion of 80-95%. Previous research has shown that these two hydrolysis techniques can yield up to 100% of glucose yield. A few studies have compared the effectiveness of these two hydrolysis methods, nevertheless. In this study, we aim to compare the glucose production as well as the advantages and disadvantages of two hydrolysis methods—acid- and enzyme-catalysed.

METHODOLOGY

Acid hydrolysis

Shredded waste paper (300mg) was loaded into a pressure tube, followed by the addition of 3mL 72wt% of sulphuric acid (H_2SO_4). After stirring using a glass rod at room temperature for one minute, the tube then was incubated in a water bath, allowing the mixture to react at 30°C for 1h. During the incubation period, the mixture was stirred using the glass rod for every 10 min interval without removing the tube from the water bath. When the incubation period has elapsed, the mixture was diluted to 4% concentration by adding distilled water (84mL). The tube was sealed tightly, inverted several times, and later autoclaved at 121°C for 1h. Next, the resultant mixture was filtered and the filtrate was neutralised by adding calcium carbonate ($CaCO_3$) until the pH reached 5-6. The mixture was allowed to stand, separating the solid and the liquid fractions. Then the liquid fraction was filtered by polytetrafluoroethylene (PTFE) filter, and later be quantified by glucometer.

Enzymatic hydrolysis

Into a 50mL-falcon tube, the following substances were added: shredded waste paper (100mg), 0.1 M of citrate buffer (pH4.7, 5 mL), tetracycline (80 μ L) and free cellulase enzyme. The volume of the sample then was increased to 10mL by adding distilled water. Next, the tube was placed in an incubator at 50°C with shaking at 150 rpm for 72h. When the incubation time has elapsed, the sample was immediately cooled in an ice bath and hydrolysate was filtered through a syringe filter. Finally, the filtrate was quantified by glucometer.

RESULTS AND DISCUSSION

The results of the hydrolysis of cellulose derived from waste paper to produce glucose when either an acid or an enzyme is used are shown in Table 1. Enzymatic hydrolysis is shown to have more glucose concentration in its mixture (0.0210mol/L) when tested with glucometer compared to that in acid hydrolysis (0.0168mol/L). However, glucose is calculated to be 40.35% and 37.77% in the hydrolysate of acid and enzymatic hydrolysis, respectively, which shows that acid hydrolysis has yielded more glucose. Nevertheless, both hydrolysis process produces similar efficiency, with acid hydrolysis of 76% and enzymatic hydrolysis of 72% (Figure 1). Thus, it can be inferred that both processes in this study successfully converted cellulose to glucose.

Table 1. Amount of glucose from glucometer testing

	Acid hydrolysis	Enzymatic hydrolysis
Concentration (mol/L)	0.0168	0.0210

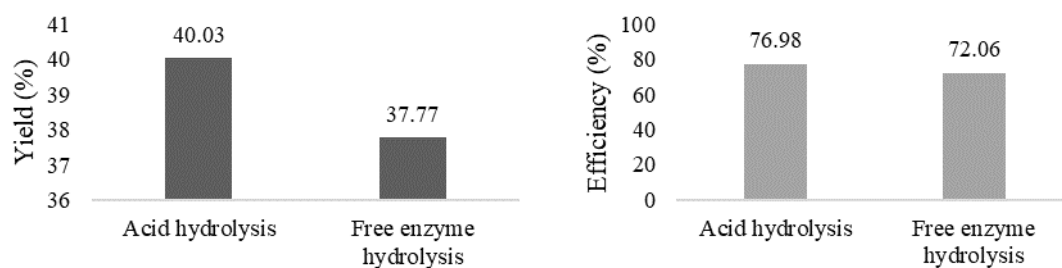


Figure 1. Glucose yield (left) and hydrolysis efficiency (right) in acid and enzymatic hydrolysis

Waste paper has been effectively hydrolysed by acid and enzymes to produce glucose with high hydrolysis efficiencies of 76% and 72%, respectively. Additionally, acid hydrolysis takes only a few hours (1-2h), whereas enzymatic hydrolysis takes at least 72 hours. However, the acid hydrolysis process has the drawbacks of being destructive to equipment and hazardous due to the usage of diluted acid (30–70% concentration) [9-10]. When performing enzymatic hydrolysis, maintaining a moderate temperature and atmosphere is not only necessary for the enzymes to function at their best, but it also has the added benefits of being safer and more environmentally friendly. Acid hydrolysis is also carried out at a high temperature (121°C). As a result, the cost of using energy might increase as well.

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