



**CALIFORNIA STATE SCIENCE FAIR  
2010 PROJECT SUMMARY**

<b>Name(s)</b> <b>Hailey C. Loehde-Woolard</b>	<b>Project Number</b> <b>J0410</b>
---	---------------------------------------

**Project Title**  
**Saccharification of Cellulose Using Acid and Cellulase Enzymes to Produce Cellulosic Ethanol, a Sustainable Fuel**

**Abstract**

**Objectives/Goals**  
The purpose of my investigation is to develop a method to convert cellulose to glucose utilizing chemical and enzymatic processes based on literature and experimental means. I will work through this process by iterating in successive experiments. Secondly, I want to confirm that the saccharide produced is glucose and fermentable by yeast.

**Methods/Materials**  
Exp #1: Add H<sub>2</sub>O to the 1st jar. Add 6 mL conc. H<sub>2</sub>SO<sub>4</sub> and H<sub>2</sub>O to the 2nd. Add 52 ml conc. H<sub>2</sub>SO<sub>4</sub> to the 3rd. Hold temp. of 80-100 C for >12 hours. Record glucose levels. Adjust pH to 4.8 and temp to 50C . Add 0.7 g of cellulase to first two jars. Hold temp for 48 hours then record glucose. Adjust temp. to 25C and add yeast. Hold for 48 hours. Record Glucose levels. Exp #2: Add H<sub>2</sub>O to the 1st set of 3 jars. Add 5 mL conc. H<sub>2</sub>SO<sub>4</sub> and H<sub>2</sub>O to the 2nd set . Add 14 ml conc. H<sub>2</sub>SO<sub>4</sub> to a 3rd set . Repeat for hydrolysis in Exp #1 but use 1.4g of cellulase in all jars. Exp #3: Use paper and 5mL acid steps from Exp#2 for 2 Jars. Place jars in pressure cooker at 15 PSI for 45 minutes. Place in microwave. Record glucose levels. Adjust pH to 4.8 and temp to 50C . Add 2.8 g and 5.6g of cellulase to each jar. Hold temp for 24 hours then record glucose. Adjust temp. to 25C and add yeast. Hold for 48 hours. Record Glucose levels. Exp. #4: Use 5mL acid steps from Exp. #2 for 3 jars of paper and 3 of newsprint. Take pH and add acid until pH is below 2. Repeat steps for hydrolysis in Exp. #3 but use 7g of cellulase in all jars.

Materials: Copy and newsprint paper; Sulfuric acid; Cellulase enzymes; Potassium hydroxide; Sodium bicarbonate

**Results**  
The highest concentration of acid from experiment #1 produced a high amount of total sugars, 5863mg. Due to side reactions, 35% of the sugar produced was not glucose. Using a moderate amount of acid in experiments 2,3 and 4 produced 100% glucose. The amount of glucose produced is correlated to the amount Cellulase used in a relationship of about 1.1:1.

**Conclusions/Discussion**  
Enzymes are critical for the efficient hydrolysis of cellulose to produce glucose and thus the sustainable fuel, ethanol. The enzyme easily unzipped the cellulose after I spent weeks trying to break the strong alpha bonds in cellulose with heat, pressure, acid and microwaves. Enzymes are amazing. More work needs to be done in this field to produce enough ethanol from cellulose to help our fuel needs.

**Summary Statement**  
Hydrolysis of cellulose by acid and cellulase enzymes to produce glucose/ethanol: Its good for the planet.

**Help Received**  
My father supported me during lab work, answered my questions and helped me learn the chemistry I needed to understand my project. He taught me how to be safe. My dad handled all of the concentrated acid/base related tasks. My mother helped me type my report and board, and internet research