CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S1107

Project Title

Paperfuture: Engineering an Enzymatic Process for Paper Waste Management

Abstract

Objectives/Goals

Paper makes up 27% of municipal solid waste in the United States. Paper towels specifically are difficult to recycle, with 55% of all paper towels ending up in landfills. Paper, a cellulosic waste, is a potential energy source. This study aims to engineer an alternative solution to paper towel disposal, in the form of an enzymatic process using CTec2 (Novozymes), to divert paper towels and produce energy by means of a microbial fuel cell or ethanol.

Methods/Materials

Twenty three paper towel saccharification scenarios were tested in triplicate, with varying buffer types, temperatures, solution ratios, agitation frequencies, pretreatment methods, duration of incubation, and sample sizes. Sugar concentration (brix), pH, and appearance were recorded periodically. Success of each scenario was determined through increase in brix and visual degradation. An incubation and agitation appliance prototype was engineered as a possible commercial application for this digestion. Ethanol was produced through fermentation.

Results

Optimal digestion environment is at an approximate pH of 5.4 and temperature of 50 degrees C. Enzyme concentrations as low as 0.25% and agitation intervals as long as 2.5 hours were effective. Moreover, pretreatment with 0.1 molar sulfuric acid neutralization with chalk increases sugar production. A 56k ohm resistor optimizes power in the microbial fuel cell (MFC). When using the resistor, a mediator, and an electron acceptor, power output increased approximately 16 times. Ethanol can be produced using the sugar resulting from digestion.

Conclusions/Discussion

Ethanol and voltage from the MFC can be generated using the digested paper towel solutions. Furthermore, the use of carbon fiber brush electrodes increases voltage. The incubator prototype was tested successfully. To make this process competitive with other paper towel disposal methods, like composting or landfilling, efficiency must be further optimized by using lower concentrations of enzyme, and designing efficiency improvements for pretreatment and energy production.

Summary Statement

We engineered an enzymatic process as an alternative solution to paper towel disposal to divert paper towels from the waste stream and produce energy.

Help Received

Dr. David Bernick, UCSC, advised the project through weekly meetings. Kurt Meyer helped with constructing the incubator prototype. Heather Grant assisted with acid dilutions.