

Bioethanol from Starch Process Simulation Tutorial on PRO II/8.2

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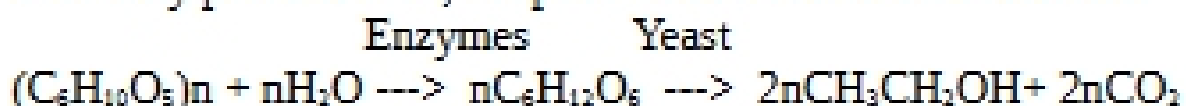
Introduction to the project:

It is essential for modern society to ensure a clean, sustainable, secure and affordable energy supply. America's current energy challenge is meeting the projected increase in energy demand while decreasing dependence on foreign sources of energy. Although petroleum provides more energy for the United States than any other resource, domestic petroleum reserves and production are very limited. As a result, imports continue to grow and have reached over 70% of the US's total petroleum consumption. A sustainable, renewable, and environmentally friendly energy resource is the desirable alternative.

Bioethanol is a liquid biofuel which can be produced from several different biomass feedstocks and conversion technologies. Bioethanol is the most employed liquid biofuel, either as a fuel or as a gasoline enhancer. It is an attractive alternative fuel because it is a renewable, bio-based resource and it is oxygenated which provides the potential to reduce particulate emission in compression-ignition engines. Bioethanol itself has a higher octane number, broader flammability limits, higher flame speeds and higher heats of vaporization than gasoline. These properties allow for a higher compression ratio, shorter burn time and leaner burn engine, which lead to theoretical efficiency advantages over gasoline in an internal combustion engine. In summary, ethanol made from biomass has the greatest advantage with regard to environment, economics, and infrastructure.

General process of Bioethanol from Starch

Ethanol is commercially produced in one of the two ways: wet mill and dry mill process. The difference is that wet milling involves separating grain kernel into its component parts, e.g., germ, fiber, protein, and starch, prior to fermentation, and dry mill process ground the entire grain kernel into flour, the starch in the flour is converted into ethanol during fermentation process, emitting carbon dioxide and distillers' grain. From chemistry point of view, the process can be written as follows:



Detailed processes are as follows (after starch-based biomass is collected and delivered to the ethanol production plant):

1. Pretreatment and milling. With dry mill process, the grain is screened to remove debris and ground into course flour. The milled grain then mixed with water to form a mash. During wet mill process, grain is soaked (steeped) in water and dilute sulfurous acid in order to separate grain into its many component parts. After soaking, the slurry is processed through a series of grinders, washing and filtering process to separate germ, fiber, and gluten, to form mash contained mainly starch and water.

2. Enzymatic hydrolysis. The mash formed at above will undergo cooking process, at which point ammonia is added acting as both pH control and nutrient to yeast, enzymes (e.g. alpha-amylase) are added to convert starch into simple sugars, such as dextrose.

3. Enzymatic hydrolysis continued. The mash is then processed with higher temperature to reduce bacteria levels, followed by pH and temperature adjustment suitable for the second enzyme. A second enzyme, usually glucoamylase is then added and the mixture is pumped into fermentation tanks.

4. Simultaneous saccharification fermentation. The glucoamylase enzyme breaks down the dextrins to form simple sugar (glucose) inside of the fermentation tanks. Yeast is then added into the tank to convert the simple sugar to ethanol and carbon dioxide. Fermentation results a mixture that contains about 15% ethanol and other materials, such as yeast, etc.

5. Distillation. The fermented mash is then pumped into a multi-column distillation system where additional heat is added. The columns use the difference of the boiling point of ethanol and water to separate ethanol from mash. Ethanol is in the stream usually can be in 95% purity with water.

6. Dehydration. The distilled ethanol is then passing through molecular sieve to physically separate the remaining water. This is based on the different molecular size to produce anhydrous ethanol for storage or usage.

Benefits of Using Model Simulation in Your Work

Model simulation is the recreation or reproduction of a particular process using computer software for analysis and forecasting purposes. Here are some benefits of using model simulation for this project.

- Anticipate potential problems and risks: Support “what if “analysis.
- Justification for process improvement and technology adoption/transfer
- Know potential outcome of process conditions
- Will have a better understanding
- Training and learning
- Optimize Bioprocess
- Generate quicker computational results
- Savings

Bioprocess Simulation Model

The process model is developed using PRO II 8.2. However, before creating a model in PRO II, the conversion rate from starch to glucose and glucose to ethanol need to be determined. The conversion rate for starch is based on the following journal article: “Parameter Estimation for Simultaneous Saccharification and Fermentation of Food Waste into Ethanol Using Matlab Simulink” by Rebecca Anne Davis. The conversion rate is based on 90 g/l of starch that produces 80 g/l of glucose which equates to 89% conversion rate.