Bioethanol Production from Lignocellulose Biomass

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Abstract

An overview of the basic technology to produce bioethanol from lignocellulose biomass is presented in this context. The conventional process includes two main steps. First, lignocellulose must be pretreated in order to remove lignin and enhance the penetration of hydrolysis agents without chemically destruction of cellulose and hemicellulose. Second, the pretreated material is converted to bioethanol by hydrolysis and fermentation. Some typical published studies and popular processing methods in attempts to improve the biomass conversion to bioethanol and increase the cost-effectiveness are also introduced briefly. Herein, the refinery of the resulted raw bioethanol mixture to obtain higher concentrated solution is not regarded.

Keywords
Bioethanol , lignocellulose ,pretreatment ,hydrolysis , fermentation Lignocellulose

Intorduction:

Cellulose and hemicellulose, like starch, are made up of sugars. However, most of the cellulose in the nature is in the form of lignocellulose. Lignocellulose is a complex structure of natural materials found in plants. It represents the most abundant source of renewable organic matter on the earth. Cheap lignocellulose biomass resources can be forestry, agricultural, and agro-industrial wastes. A variety of such materials can be mentioned here including sawdust, poplar trees, sugarcane bagasse, brewer's residue, grasses and straws, stems, leaves, husks, shells, and peels from grains, corn, sorghum, and barley. In contrast to a desire of utilizing these materials to produce valuable products, lignocellulose wastes are still accumulated every year in large quantities, causing environmental problems.

Lignocellulose consists of cellulose, hemicellulose, and lignin and always exists beside other extracts and mineral traces. The general composition of lignocellulose is presented In lignocellulose, cellulose fiber strands are formed by cellulose linking to each other via hydrogen bonding. The cellulose structure within the polymer is not homogenous. Crystalline regions are where cellulose Nano-fibrils are organized in order and compact, while amorphous regions are disordered and easier to be hydrolyzed. Cellulose fibers are like skeletons surrounded by hemicellulose and lignin. This structure naturally protects the polysaccharides from hydrolysis by enzymes and chemicals, thus raising a difficulty in both chemical and bioconversion of lignocellulose to other products,i.e., ethanol.

In lignocellulose, besides cellulose, hemicellulose is also a noticeable polysaccharide. Hemicellulose is a linear and branched heterogeneous polymer typically made up of five different sugars—L-arabinose, D-galactose, D-glucose, D-mannose, and D-xylose. The backbone of the chains of hemicelluloses can be either a homopolymer or a heteropolymer (mixture of different sugars).
Hemicelluloses differ from cellulose not only by the different sugar units but also by their molecular morphology of being amorphous, where shorter chains are branching from the main chain molecules. As a result of this chemical characteristic, hemicellulose is easier to be hydrolyzed than cellulose .

Mechanical processes reduce the size of the biomass and thus enhance the contact surface. Mechanical processes do not change the chemical properties of the materials. Therefore, they just can be a step to process raw materials before other steps of the pretreatment. Cutting, crushing, milling, and grinding can be carried out with specific equipment.

Conversion of pretreated lignocellulose to bioethanol

Pretreated biomass can be converted to bioethanol by both direct microbial conversion (DMC) and hydrolysis along with fermentation . In fact, DMC method requires much time, while the conversion yields were rather low with high risk of contamination . In contrast, enzymatic hydrolysis combining microorganism fermentation is a more preferable method with proven much better performance .

Saccharification of lignocellulose

After lignocellulose being pretreated, the polysaccharide-enriched material is hydrolyzed to single sugars (hexoses and pentoses) with enzymes. The commercialized enzyme to hydrolyze cellulose and hemicellulose is in fact a mixture of some different kinds of enzymes, commonly called cellulase, extracted from microorganism. These enzymes cleave glycosidic linkages in carbohydrates, typically via inverting or retaining mechanisms, the latter of which proceeds via a two-step mechanism that includes formation of a glycosyl-enzyme intermediate .

Fermentation

Microorganisms are employed to metabolize the liberated single sugars from enzymatic hydrolysis to convert them to bioethanol. There are two approaches:

- Separate hydrolysis and fermentation (SHF): the hydrolysis is carried outuntil
- finish, and then microorganisms are added to the mixture to ferment the sugars. This method has some inherent weak points, including contamination, formation of inhibitors, and requirement of more time andextra equipment.
- Simultaneous saccharification and fermentation (SSF): the enzymatic hydrolysis and microorganism fermentation are carried out in the same equipment at the same time. Both enzymes and microorganisms are loaded to the mixture. This method is proven much better than the SHF above withshorter time, less equipment, and minimized risk of contamination.

SSF is currently considered the optimal method to convert lignocellulose to bioethanol. The process is reported with high conversion yield . However, there are still some small backwards of this method. The optimal temperature for enzymatic hydrolysis is 45–50°C, while fermentation is at its highest efficiency at 28–35°C. Moreover, some intermediate products also resist the growth of microorganisms

Material & Method

Raw material such as poplar trees, sugarcane bagasse, brewer's residue, grasses and straws, stems, leaves, husks, shells, and peels from grains, corn, sorghum, and barley.

Enzyme

H2so4,and Hcl

Microorganism -Saccharomyces cervices

Process

To take a poplar trees, sugarcane bagasse, brewer's residue, grasses and straws, stems, leaves, husks, shells, and peels from grains, corn, sorghum, and barley.

↓

Crused it

↓

This crushed volume to add enzyme (lignocellulase or cellulase) for hydrolysis

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After hydrolysis this volume taken by fermentation adding Saccharomycescervices for 24-32 hrs.

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After fermentation send distillation

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Separate the Alcohol

Conclusion

Renewable fuels and energy are a vital demand of the human being when fossil resources are exhausted and the global warming is at the red alarming level. The production of lignocellulosic bioethanol can meet the requirement of food security and the sustainable vision of a green world. The process includes pretreatment, enzymatic hydrolysis, and fermentation stages. Intensive studies are being carried out in over the world, in order to increase the cost-effectiveness of ethanol production and to make the transition from the laboratory to the industrial/commercial scale. This brief background was written in hope to spot out some noticing information for the readers about lignocellulose-based bioethanol's technology, which currently attracts a lot of studies to shorten the gap between research and commercialization.

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