Synthesis of Bio Ethanol by using Bio waste material

[1]Dr.K.Mahammad Rafi, [2]Mr. G.Tirumalaiah

[1]Associate Professor, [2]Assistant Professor
Chaitanya Bharathi Institute of Technology, Proddatur, Kadapa dist,

***Abstract*: Lignocellulosic contain Bio waste biomass can be utilized to produce ethanol, a promising alternative energy source for the limited crude oil. There are mainly two processes involved in the conversion: hydrolysis of cellulose in the lignocellulosic biomass to produce reducing sugars, and fermentation of the sugars to ethanol. The cost of ethanol production from lignocellulosic materials is relatively high based on current technologies, and the main challenges are the low yield and high cost of the hydrolysis process. Considerable research efforts have been made to improve the hydrolysis of lignocellulosic materials. Pretreatment of lignocellulosic materials to remove lignin and hemicellulose can significantly enhance the hydrolysis of cellulose. Optimization of the cellulase enzymes and the enzyme loading can also improve the hydrolysis. Simultaneous saccharification and fermentation effectively removes glucose, which is an inhibitor to cellulase activity, thus increasing the yield and rate of cellulose hydrolysis.**

***Keywords*: Cellulase; Cellulose; Ethanol; Fermentation; Hydrolysis; Lignocellulosic biomass; Pretreatment**

1.0: Introduction:

1.0.1: Lignocelluloses Biomases:

Lignocellulosic biomass refers to plant biomass that is composed of cellulose (40-60%), hemicellulose (20-40%), and lignin (15-25%). The carbohydrate polymers (cellulose and hemicelluloses) are tightly bound to the lignin. Lignocellulosic biomass can be grouped into four main categories: agricultural residues, Forestry residues, Energy Crops, Bio waste streams.
Agricultural residues: corn stover, straw, etc. can be used for production of second generation biofuels.
Forestry residues: residues from harvest operations that are left in the forest after stem wood removal, such as branches, foliage, roots, etc. and complementary fellings.
Energy Crops: energy crop are specifically bred and cultivated to produce biomass which are used in biorefinery concepts or to release energy either by direct combustion or by biogas.
Biowaste streams: municipal solid waste (mainly kitchen and garden waste), packaging waste wood, household waste wood, market waste, food processing wastes etc.

Fig. 1: Wood Waste

Fig.3: lignocelluloses biomass.

1.0.2: Cellulose:

Cellulose is an organic compound with the formula $(C_6H_{10}O_5)_n$, a polysaccharide consisting of a linear chain of several hundred to over ten thousand β(1→4) linked D-glucose units. Cellulose is the structural component of the primary cell wall of green plants, many forms of algae and the oomycetes. Some species of bacteria secrete it to form biofilms. Cellulose is the most common organic compound on Earth. About 33% of all plant matter is cellulose (the cellulose content of cotton fiber is 90%, that of wood is 40–50% and that of dried hemp is approximately 75%).For industrial use, cellulose today is mainly obtained from wood pulp and cotton. Cellulose is mainly used to produce paperboard and paper; to a smaller extent it is converted into a wide variety of derivative products such as cellophane and rayon. Converting cellulose from energy crops into biofuels such as cellulosic ethanol is under investigation as an alternative fuel source.Some animals, particularly ruminants and termites, can digest cellulose with the help of symbiotic micro-organisms that live in their guts. Humans can digest cellulose to some extent, however it mainly acts as a hydrophilic bulking agent for feces and is often referred to as "dietary fiber"

1.0.3: Hemi Cellulose:

A hemicellulose is any of several heteropolymers (matrix polysaccharides), such as arabinoxylans, present along with cellulose in almost all plant cell walls. While cellulose is crystalline, strong, and resistant to hydrolysis, hemicellulose has a random, amorphous structure with little strength. It is easily hydrolyzed by dilute acid or base as well as myriad hemicellulase enzymes.Hemicelluloses include xylan, glucuronoxylan, arabinoxylan, glucomannan, and xyloglucan.

These polysaccharides contain many different sugar monomers. In contrast, cellulose contains only anhydrous glucose. For instance, besides glucose, sugar monomers in hemicellulose can include xylose, mannose, galactose, rhamnose, and arabinose. Hemicelluloses contain most of the D-pentose sugars, and occasionally small amounts of L-sugars as well. Xylose is always the sugar monomer present in the largest amount, but mannuronic acid and galacturonic acid also tend to be present.
Unlike cellulose, hemicellulose (also a polysaccharide) consists of shorter chains – 500–3,000 sugar units as opposed to 7,000–15,000 glucose molecules per polymer seen in cellulose. In addition, hemicellulose is a branched polymer, while cellulose is unbranche.

1.0.4: Lignin:
Lignin or **lignen** is a complex chemical compound most commonly derived from wood, and an integral part of the secondary cell walls of plants[1] and some algae.[2] It is one of the most abundant organic polymers on Earth, exceeded only by cellulose, employing 30% of non-fossil organic carbon,[4] and constituting from a quarter to a third of the dry mass of wood. As a biopolymer, lignin is unusual because of its heterogeneity and lack of a defined primary structure. Its most commonly noted function is the support through strengthening of wood (xylem cells) in trees.

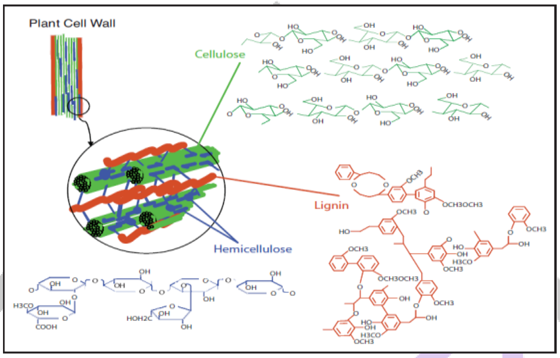

Fig.5: Structures of Lignocellulose molecules

2.0: Methodolgy:
2.0.1: Production of Bio Ethanol:
In principle, biochemical conversion of lignocellulosic biomass to ethanol can be described as the fermentation of sugars liberated from the feedstock.Conversion of sugar and starch to ethanol is well established technology, but has certain limits. These crops have high value for food applications and their sugar yield per hectare is very low compared to the most prevalent forms of sugar in nature. The potential of lignocellulosic biomass is therefore considerable large than the crops and starch. However, a main challenge is to obtain the utmost efficiencies to convert biomass to sugars (saccharify) and ferment these impure sugars to ethanol or butanol.
This consists of the following;

i- Biomass raw materials, which include, agriculture residues, energy crops and solid waste,
ii- pretreatment, mechanical, acid, alkali, and solvent,
iii - enzymatic cellulose hydrolysis,
iv- organic, C5, C6, and C5/C6 fermentation, and
v- Product recovery, ethanol or butanol, and lignin utilization.

2.0.2: Pretreatment of lignocelluloses biomass
Pretreatment refers to the solubilisation and separation of one or more components of the biomass (hemicelluloses, cellulose, and lignin) to make the remaining solid biomass more accessible to further chemical or biological treatment. This a main processing challenge in the ethanol production from lignocelluloses biomass. The goal of pre-treatment is to remove lignin and hemicelluloses, reduce cellulose crystallinity and increase the porosity of the biomass,

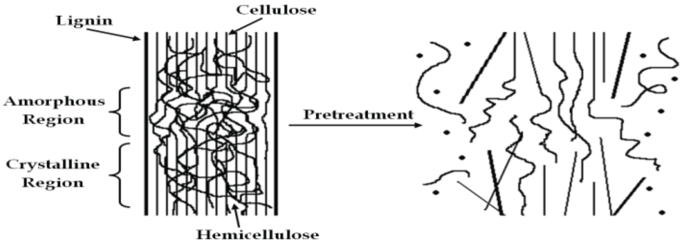

Fig.6: Pretreatment of LB

2.0.3: Pretreatment Using dilluted Sulfuric Acid

A complete and fast conversion of cellulose to glucose and hemicelluloses to C5-sugars is achieved using concentrated sulphuric acid. This process needs relatively mild temperatures and pressures as such sugar degradation is minimized. High sugar recovery efficiency, as well as the potential for cost reduction is the most significant advantages of this process

Prepare 200ml of diluted sulfuric acid of 0.5M. Immerse 10g of Biomass into the diluted sulfuric acid. Heat the mixture at 100℃ for different time variation of 2 hours, 3 hours, 4 hours and 5 hours. After the newspaper become floc, filter the mixture and keep the residue for hydrolysis.

Fig.7: Pretreament with dlute sulfuric acid

2.0.4: Preatment Using Concentrated Zinc Chloride:

Prepare 30ml concentrated zinc chloride by dissolve 70g solid zinc chloride into 30g water. Immerse 4g of Biomass (to save the chemicals) into the concentrated zinc chloride. Heat the mixture at 120℃ of different time variation of 1 hour, 2 hours and 3 hours. After the Bio mass is completely dissolved, add to extract cellodextrin for further hydrolysis.

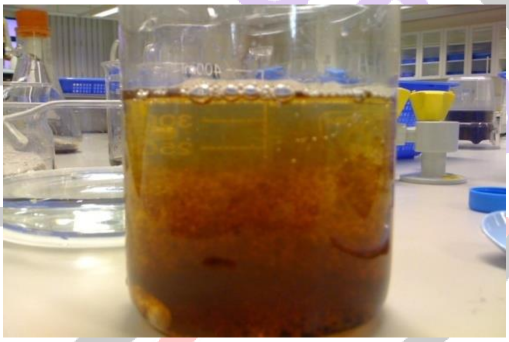

Fig.8: Pretreatment with Concentrated Zinc Chloride - Celludextrin

The cellulose molecules are composed of long chains of sugar molecules. In the hydrolysis process, these chains are broken down into the sugar for further fermentation into alcohol production.

2.0.5: Ethanol fermentation by Yeast cells:

The overall process of fermentation is to convert glucose sugar ($C_6H_{12}O_6$) to alcohol (CH_3CH_2OH) and carbon dioxide gas (CO_2). The reactions within the yeast cell which make this happen are very complex but the overall process is as follows:

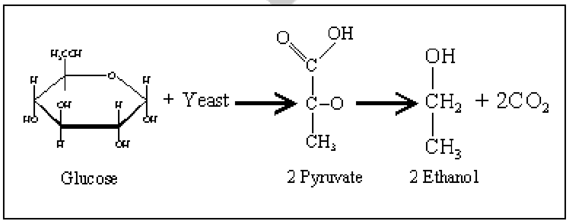

Fig.9: Chemical reaction for Fermentation process

$C_6H_{12}O_6 \Rightarrow 2(CH_3CH_2OH) + 2(CO_2)$ + Energy (which is stored in ATP)
Sugar (Glucose) Alcohol (Ethyl alcohol) Carbon dioxide gas Energy

From the above one mole of glucose is converted into two moles of ethanol and two moles of carbon dioxide but in reality it is far from this clear. There are many by products. In addition to CO_2 and alcohol, the sugar is incorporated into other by products such as yeast biomass, acids (pyruvic, acetaldehyde, ketoglutaric, lactic), glycerol.after that by fractional distillation we will get pure ethanol.

3.0: Conclusion:

The production of biofuels from lignocellulosic material in Norway has many advantages. Reduced CO_2 emissions, increased employment in rural areas, increased energy security, higher national income from increased crude oil sales abroad, possible technology transfer to abroad, cleaner burning resulting in better air quality in urban areas and a new industry enabling a less oil dependent economy and energy system, are some of the reasons to introduce biofuels produced from wood. The fuels may be used in existing infrastructure and engines, thereby leap-frogging one of the major barriers to hydrogen and other future fuel alternatives. Looking at alternatives to conventional fuels, one should consider biomass to decrease $CO_{2\text{-eq.}}$ emissions but also due to competing energy efficiency, in fuel production as well as in electricity production.

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