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Green Fuel Bio-Ethanol from Agriculture Waste Wheat Straw

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Abstract: *In India molasses availability is govern by sugar production and which meets the present of alcohol demand and also the harmful effects on the environment. Wheat Straw is new upcoming raw material for production of ethanol. Ethanol is potentially used for potable purpose and as solvent in chemical industries. Bio-ethanol has nonpolluting properties. Indian government has started 5% blending of ethanol with petrol. Presently in India ethanol is manufacture by petroleum and molasses rout. But demand of power ethanol is so high that existing supply cannot meet demand. It is very necessary to shift for another renewable raw material recourses when pollution problem are taken into consideration for the molasses process. The adverse effect on environment is very harmful in molasses.*

Bioconversion of cereal straw to bioethanol is becoming an attractive alternative to conventional fuel ethanol production from grains. In this work, the best operational conditions for steam-explosion pretreatment of wheat straw for ethanol production by a simultaneous saccharification and fermentation process were studied, using diluted acid [H2SO4 0.9 % w/w)] and water as preimpregnation agents. Acid- or water-impregnated biomass was steam-exploded at different temperatures (160–200°C) and residence times (5, 10, and 20 min). Composition of solid and filtrate obtained after pretreatment, enzymatic digestibility and ethanol production of pretreated wheat straw at different experimental conditions was analyzed. The best pretreatment conditions to obtain high conversion yield to ethanol (approx 80% of theoretical) of cellulose-rich residue after steam-explosion were 190°C and 10 min or 200°C and 5 min, in acid-impregnated straw. However,180°C for 10 min in acid-impregnated biomass provided the highest ethanol yield referred to raw material (140 L/t wheat straw), and sugars recovery yield in the filtrate (300 g/kg wheat straw).

Keywords: *Wheat straw, ethanol, diluted acid pretreatment, steam-explosion.*

1. Introduction

1.1 Lignocellulosic Biomass:

In recent years, Lignocellulosic biomass, especially agricultural crop residue, is being investigated for ethanol production because they are cheap, easily available, & require in time removal from the field. The main constituents of, Lignocellulosic biomass are cellulose, hemicelluloses, & lignin & minor components include ash & extractive such as waxes. Cellulose, existing in the form of micro fibrils which are Para-crystalline assemblies of p-1, 4 glycosidic bonded D-glucose chains with hydrogen bonds connected to one another, can be hydrolyzed into glucose. Hemicellulose is a complex, highly branched network of monomer which are heterogeneous mixtures of hexoses (glucose, galactose and mannose) and pentose (arabinose & xylose). Cellulose and hemicelulose structure are surrounded by a lignin sheath which is a three dimensional phenyl propane polymer with phenyl propane units held together by ether and carbon-carbon bonds.

Lignin strengthens structure by stiffening and holding the fiber of polysaccharides together, therefore posing as an obstacle during hydrolysis of the Lignocellulosic biomass. Based on **the** specific lignocellulosic structure, the common bio-ethanol process employs three steps **including pretreatment,** hydrolysis and sugars fermentation. Pretreatment reduces the size and breaks down the lignin & crystalline structure of Lignocellulosic biomass, thus facilitating the subsequent hydrolysis of cellulose and hemicelluloses. The hydrolysis step employs physiochemical (concentrated acids hydrolysis at low dilute acid hydrolysis at high temperature) or enzymatic (enzymatic hydrolysis) approaches to convert cellulose and hemicelluloses into sugars. The sugars are finally fermented by yeasts or bacteria to ethanol. Examples of lignocellulosic crop residues being focused on include corn stover (stalks, leaves, husks and cobs), wheat straw, & rice straw. With approximately 80 million acres of corn planted annually, corn stover is expected to become a major biomass resource for bio-energy application in the United States. However, this quantity is not sufficient to meet all the fuel and power needs thus alternative lignocellulosic feed

1.2 Wheat straw:

From a mere 12 million tons (MT) inl965, India produced, 76.37 MT of wheat in the year 2000. India's ability to meet the projected 109 MT wheat demand by 2020. Wheat is one of the most abundant crops in India which is an important source of lignocellulosic biomass. Straw waste is left in the field every year.

1.3 Pre-treatment method:

The goal for the pretreatment is to make it easier for the enzymatic hydrolysis. There are many ways of pre-treating the material; it can be done chemically, physically, biologically or as a combination of these. The pre treatment with steam can be done with and without catalyst a higher yield is obtained with a catalyst. In this study the pretreatment with sulphuric acid as a catalyst. In the steam pre-treatment the straw is exposed to steam with high pressure. The water inside the cells evaporates and as the pressure around the straw drops the straw explodes. The explosion increases the specific area. Parts of the hemicelluloses the decomposition to acid which catalyses the decomposition of hemicelluloses and lignin, and releases the cellulose. In this study the temperature was varied between 190°c & 210°c & the residence time between 2 & 10 min, but the concentration of the sulphuric acid was set to 0.2% by weight. The slurry from the pre-treatment was filtered before enzymatic hydrolysis.

1.4 Enzymatic hydrolysis:

Hydrolysis of the cellulose can be done with acids or with enzymes. The disadvantage when using acids are:

- No selectivity
- By-products formation
- Need of high temperature (140-160°c)
- Demand of neutralization after the hydrolysis
- Corrosion problems

The enzymes on the other hand are selective, results in a relatively high yield and the hydrolysis is done at lower temperature. There are three different enzymes needed for the enzymatic hydrolysis of cellulose. Endo-glucanase splits the long chains of cellulose to shorter. Cellobiohydrolase cleaves units of two linked glucose molecule (cellobiose) from the ends of the cellulose chain. Finally P-glucosidase cleaves cellobiose into glucose molecule. Most cellobiose and P-glucosidase have an optimum at 50 + 5°c & pH 4.0-5.0. Cellobiose inhibits cellulose, but the concentration of cellobiose is rather low since p-glucosidase cleaves cellobiose. Glucose on such a large amount straw waste brings about not only environmental problem due to disposal issues, but cotton diseases and pests. Therefore studies are urgently required to solve the wheat straw waste problems. Bio-ethanol production technology is one of the approaches that can help utilize this waste and generate profit.

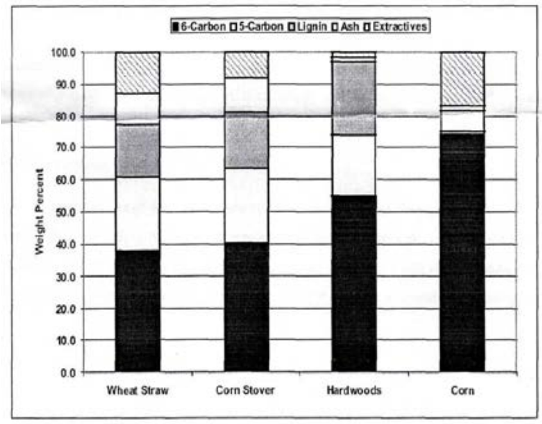

Figure- Wheat straw in comparison with other lignocelluloses material

2. Materials and methods

2.1 Preparation of lignocelluloses substrate:

The straw was cut into the pieces up to 6-8 cm long by a forage harvester and stored in a container at ambient temperature. The dry matter content was approximately about 90% (w/w). Before experimentation it was air dried after rinsing with tap water. The dried biomass was chopped up to 15-20 mm in size. The substrate was autoclaved 20-25 min with 2% by weight of sulfuric acid and supernant solution was obtained by centrifugation. The dry sample had 10% moisture content. The other hand inhibits p-glucosidase. During the steam pretreatment some aromatic compounds are formed, from the lignin, which can inhibits both the hydrolysis and the fermentation. [2]

2.2 Fermentation method:

The sugar formed in the hydrolysis is fermented into ethanol. The most common microorganism for this purpose is Saccharomyces cerevisiae, which is the same that is used in ordinary backing yeast S. cerevisiae ferment glucose and mannose. Glucose was added so that all the filtrates and & the reference had the same concentration of fermentable sugar, 50 g/1. The fermentation conditions were 30°c and pH 5.5. Samples were withdrawn during the fermentation and analyzed

2.3 Inoculums cultures:

A small amount of pure baker's yeast culture was transferred from an agar plate to a 250 ml shake flask containing 100 ml sterile medium. The medium with a pH of5.5, consisted of 20 g/1 glucose, 208 ml/1 salt solution, 12.5ml/l trace metal solution and 1 ml/1 vitamin solution. The culture was incubated at 30°c for 24hrs, during which the flask was sealed with a cotton wool

2.4 Plug-Straw composition analysis:

The composition of the straw analyzed using two-step acid hydrolysis according to the procedure published by the National Renewable Energy Laboratory (NREL). The dried samples were treated with 3 ml of 72% H_2SO_4 and placed in a water bath with a temperature of 30°c. The samples were diluted with 84 ml of Milli-Qwater to give a H_2SO_4 concentration of 2.5%. The samples were autoclaved for l hrs at 121°c. After cooling, 20 ml of the sample was neutralized with CaODs to pTTS^STTvionosaccharide concentration was analyzed by HPLC. Results are given as glucan (nearly all d-glucose originates from cellulose) and hemicellulose: d-arabinose nd d-xylose in straw (mainly arabinoxylan) and D- arabinose, D-xylose, D-mannose, D-galactose in spruce (mainly galactoglucomannan).

Design of Model:

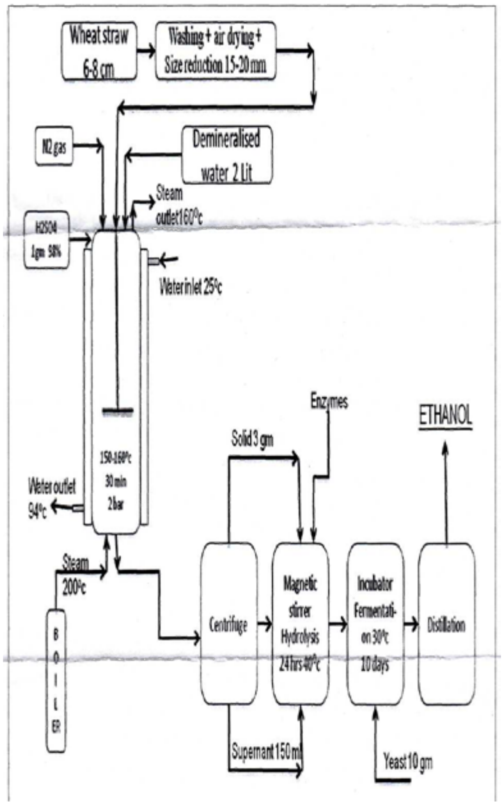

Figure: - Block diagram of the model

3. Conclusion:

In this seminar we have focused on the manufacture of bio-ethanol from wheat straw. The literature suggests that use of wheat straw as a potential raw material for the production of ethanol to meet the ever-increasing demand of alcohol. With change in present molasses route i.e. by adding an additional pretreatment process and remaining process is same. There are various pretreatment available from which selection of one should be done in proper manner. Pretreatment is the most important process in which temperature condition parameter was observed very important. If there is large temperature decrease in pretreatment of wheat straw, lignin cannot be separated properly. Pressure is also an important parameter. For the proper hydrolysis of pretreatment wheat straw sterilization and proper cooling conditions are necessary. The fermentation must be carried out in presence of yeast. Fermentation must be carried out in an ideal condition for more conversion of sugar to ethanol. After the conversion of ethanol, distillation process is been used. For more percentage of ethanol more distillation columns should be used. Single distillation column gives less purity.

The cost required for the pretreatment increases the overall cost but as wheat straw is an agro-waste the production cost is not required and balances the overall cost. No pollution problems are created due to reuse of waste coming out for the boiler feed and electricity production. The overall process is pollution free, cost effective, reducing agro-waste disposal problem, satisfying the ethanol demand and saves foreign exchange reserves.

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