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Review Article

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Methods of Pre-Treatment through Wheat Straw: A Review

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ABSTRACT

Wheat straw is abundantly found agriculture waste having low commercial low value. Wheat straw is lignocellulosic biomass which can be used for the production of bioethanol. As fuels are depleting source of global world so ethanol can be used for alternative source. Pre-treatment method is used for lignocellulosic biomass for improving the hydrolysis of the wheat straw as it contains high amount of cellulose and removal of lignin and hemicellulose. Cellulose convert into the reducing sugars and then to the ethanol. Presented review paper focus on the methods of pre-treatment.

Keywords: Bioethanol; Fermentation; Pre-treatment; Hemicellulose; Ethanol

INTRODUCTION

Wheat straw is the enriched biomass having lignocellulosic composition consist mixture of cellulose, hemicelluloses and lignin. Wheat straw is agricultural waste slightly different from others like rice straw sugarcane bassage. In bioethanol production the main three processes are pre-treatment, hydrolysis and fermentation [1]. Wheat straw is renewable and good source for producing low-cost ethanol. All the lignocellulosic materials consist of sugars, which by different processes are converted into ethanol. Commonly used microorganisms for the process are *Saccharomyces cerevisiae* and *Zymomonas mobilis* [2]. Lignocellulosic components as cellulose (40-50%), lignin (15-20%) and hemicellulose (25-35%) are some or more resistance for hydrolysis so pre-treatment is required for the production [3]. Pre-treatment breakdown the lignin and helps during the hydrolysis for production of bioethanol and white rot fungus is one of the effective methods among biological pre-treatment [4].

Pre-treatment

Pretreatment is mainly used for removal of lignin and hemicelluloses and deflate cellulosic crystallinity. Pre-treatment prevent the loss of carbohydrates and avoid the production of any other byproduct which can act as inhibitory during the further process, hydrolysis and fermentation [5]. There are many methods for the process available used according to the cost effective and performance. Pretreatment is the most typical method among all other [6].The main methods of the pre-treatment are Physical, Physico-chemical, Chemical and Biological [1].

Physical method:

Physical pre-treatment methods involves Mechanical size reduction method, Pyrolysis, Microwave oven and electron beam irradiation pretreatment [7].

Mechanical size reduction: Milling is cutting of wheat straw into small pieces performed by using laboratory knife [8]. Size of material is normally 10-30 mm after cutting in small pieces and 0.2-2 mm afterwards the milling (more effective) or grinding [5]. The different milling processes are Ball milling, Two-roll milling, Hammer milling, Colloid milling, Vibro energy milling [9].

Pyrolysis: Pyrolysis is other method of pretreatment. Wheat straw or any lignocellulosic material are treated at more than 300°C temperature resulted in decomposition. At lower temperature they form product is less volatile and formation is also slow. Presences of oxygen lead to accelerate the process [5].

Microwave oven and electron beam irradiation pre-treatment: Microwave oven pre-treatment improves the substrate by-product more susceptibility to the further process of hydrolysis. Optimal conditions such as temperature (110°C to 210°C) and duration 20 to 60 minutes and inquisited with addition of 0.5% H_2SO_4 [10]. Electron beam irradiation method is non- thermal method. By the method continuous magnetic field for the disruption and high energy radiation results in changes in the given biomass consist with increase in specific surface area and depolymerisation of lignin [7]. Gamma irradiation pretreatment accelerates the acidic and enzymatic hydrolysis of lignocelluloses biomass [11].

Extrusion: Treatment is done with high temperature that is more than 300°C. Physical changes in cellulose occur by mixing and shear force on sample. Extrusion retreatment method is known as novel technique for the bioethanol production [12].

Physico-chemical method:
The method involves steam explosion, ammonia fibre explosion:
Steam explosion: Also known as auto hydrolysis is biomass dissolution processed. In the process high pressure (13 atm) and temperature (180°C) [13]. Optimum condition provide to the chamber in which the wheat straw or any other sample in the chips form. Pressure is released after 1-5 minute result in steam explosion in sample and disintegrates individual fibres along with less damage to the sample [14].

CO_2 explosion: Method is similar to the steam explosion as the difference in this pre-treatment method CO_2 is used that carbonic acid enhances the rate of hydrolysis. Comparison among the CO_2 explosion method and steam explosion, CO_2 explosion is cost-effective and also not form the inhibitory components which are formed by the steam explosion [15].

Ammonia fibre explosion: In AFEX process wheat straw is exposed to liquid ammonia at controlled temperature and high pressure pursue by fast release of ammonia. This process enhances the access of surface area for enzyme and lessens the cellulose crystallinity. Ammonia reaction helps in altering the lignin structure and improves in hydrolysis [16].

Chemical method:
Acid pre-treatment method: Acid pre-treatment process is carried out with concentrated or diluted acid. Concentrated acids as H_2SO_4 and HCL are used for the treatment [5]. High temperature (180°C) with resident time or lower temperature (120°C) for longer time (30-90 mintues). Method is Useful for solubilising hemicellulose [17].

Alkaline Pre-treatment: Alkaline pre-treatment is used for delignification which is useful for the conversion of glucose to ethanol. Reaction like solvation and saphonication take place [18]. Sample soaked in hydrogen peroxide (H_2O_2) solution (1%), accommodate to different pH (8, 11.5 or 13) with addition of sodium hydroxide (NaOH) repeated accordingly and then the residue is dried [19]. Efficient method, avoid accumulation of inhibitory byproduct and can be used with sample having high rate of lignin content [20].

Dilute method: Milled sample slurried in diluted H_2SO_4 or water and treated within autoclave at 15 psi pressure and 121°C for 1 hour or sand bath with different temperature (140, 160, 180°C) for 15 minutes. Before enzymatic saccharification pretreated straw sample acclimatize to pH 5 with NaOH (10 M) or $Ca(OH)_2$ [21]. Both nitric and sulphuric acid provides good result, but acids higher prices shortlist this method in less cost effective [20].

Ozonolysis: In this pre-treatment method Ozone is used for the degradation of lignin and other components present in the lignocellulosic materials. This method efficiently removes lignin, also no production of toxic and inhibitory components and under normal temperature and pressure is required for carrying out the process. This method is having high cost because of huge amount of ozone is required [5].

Organosolv process: In this method wheat straw is treated at temperature at 150-200°C and addition of catalysis is optional those are salicylic, oxalic and acetyl -salicylic acid [5]

Biological method:

In biological pre-treatment method wheat straw is treated with microorganism to enhancing action for enzymatic hydrolysis. Microorganism help in degradation of lignin and cellulose as cellulose is more resistant than other component present in lignocelluloses [22]. Wood attacking microorganism are used are brown rot, white rot, red rot these three classes of microorganism in which cellulose is attacked by brown rot and lignin by other two rot [23]. Most effective fungi are white rot like *Phanerochaet Chrysosporium* releases lignin degrading enzymes [24].The fungi used for the biological pre-treatment should have several properties as high affinity to lignin and degradation of polymeric organic structures of lignocellulosic components. Other like *Aspergillus niger* and *Aspergillus awamori* also shoes good results in production after fermentation [1].

CONCLUSION

For production of bioethanol different pre-treatment methods has been described. Wheat straw is lignocellulosic biomass consisting of lignin, cellulose and hemicellulose. Cellulose and hemicellulose have shorter chains of sugar units and differ in structure as cellulose is unbranched and hemicellulose is having branched polymer During the production of bioethanol lignin contribute as the inhibitor because lignin belongs to complex organic polymer and chemically, lignin referred as polymer of phenolic so pre-treatment process is performed so that further process can be performed easily. The process as physical, chemical, biological pre-treatment is used. The most effective and promising method is chemical pre-treatment method in which dilute acid is considered effective but also the cost is high. However pre-treatment method relies on the composition of biomass and different operational conditions. All given method have different processing procedures, advantages and disadvantages. As biological method is the slowest pre-treatment method. Also none of pre-treatment methods 100% biomass conversion of reducing sugars to bioethanol.

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