Chapter 18
Pretreatment of Lignocellulosic Biomass and 2G Ethanol

Hitesha J. Panchal
Parul University, Vadodara, India

Krishan Kumar
Parul University, Vadodara, India

ABSTRACT

Rapid depletion of fossil fuel-based energy sources increased the demand for alternate energy sources. Lignocellulosics-based 2G ethanol can be used as an alternative sustainable source that presents in ample amount. Sources of lignocellulose biomass are wood, food-agriculture wastes, and forest residues. Cellulose, hemicellulose, and lignin are the core components of lignocellulosic biomass. Cellulosic and hemicellulosic biomass are enzymatically hydrolyzed to produce the monomer sugar (such as glucose or xylose) which is further converted into ethanol using fermentation process. The presence of lignin provides physical barrier that limit the access of enzymes required for saccharification. Pretreatment helps in removing the lignin from biomass and reducing recalcitrance. Pretreatment can be done by conventional methods, which are chemical, physical, and biological. This study covers the different methods of pretreatment including their disadvantages and benefits along with saccharification and fermentation processes.

INTRODUCTION

Globally, the rapid use of energy causes the rapid reduction of fossil fuel-based energy sources. Also, the chief concern with its frequent use is that it releases harmful (unfavourable) gases like methane, CO, CO_2, nitrous oxide, etc. which are known as greenhouse gases (Houghton, 2005). Since these energy sources are vanishing, we need to emphasis on finding its sustainable alternative source. The goal should be to develop a long-term sustainable energy source that emphasizes “recovery and reuse” of bio-derived raw materials.

DOI: 10.4018/978-1-6684-5269-1.ch018

Lignocellulosic biomass (LCB) has acknowledged a lot of interest as a renewable, sustainable energy source. LCB has the potential for meeting future energy requirements while posing no environmental risks (Ahmad *et al*.,2020). Wheat straws, rice husk, sugarcane bagasse, forest and agricultural wastes, industrial and urban trash might all be good sources of lignocellulosic biomass (LB) (bioethanol) (Zheng *et al*., 2014; Amin *et al*., 2017).

Traditionally, sugar and starch-based feedstocks including sugarcane juice and molasses, as well as corn, have been used to make bioethanol (Balan *et al*., 2013). Bioethanol is currently being generated on a commercial scale using lignocellulosic feedstocks (Balan *et al*., 2013). LBM is the most abundant raw material found in nature which includes sources like hardwood, grasses, softwood, agricultural wastes, etc. Newsprint, office paper, municipal solid wastes, and other raw materials might be of interest as well. Starch is a simple substrate, whereas lignocellulosic biomass is more complicated. Second generation (2G) ethanol is less trending when compared to the first generation ethanol, and it is still less economical due to its high cost (Furlan *et al*., 2013; Macrelli *et al*., 2014). Several research of sugarcane bagasse-based 2G ethanol production techniques have been conducted. In one study, enzymatic hydrolysis of sugarcane bagasses after diluted acid pretreatment produced fermentable sugar for high yield bioethanol production (Benjamin *et al*., 2013; Albuquerque *et al*., 2013).

Lignocellulosic biomass is made of three key components which are cellulose, hemicellulose, and lignin. In which cellulose is the polysaccharide present in great amount therefore known as the most abundant LBM. Cellulose is the linear chain of glucose linked via β-1,4 glycosidic linkages. Hemicellulose is branched heteropolymer whereas coniferyl alcohol, sinaphyl alcohol and p-coumaryl alcohol make form the three-dimensional macromolecule lignin. Lignin causes the recalcitrance in the LBM (Alonso *et al.,*2012).

Since this recalcitrance of lignocellulose biomass is being the hurdle in bioethanol production, so, it should be reduced to get efficient yield of bioethanol. The recalcitrance of biomass can be reduced by using numerous pretreatment methods like chemical pretreatment, biological and physical pretreatment. By doing pretreatment we can increase the enzyme accessibility and hydrolysis of cellulose and hemicellulose polysaccharides, which further leads to higher bioethanol yield.

LIGNOCELLULOSIC BIOMASS

Lignocellulosic biomass is ubiquitous and sustainable resource which is composed of polysaccharides (cellulose and hemicelluloses) and an aromatic polymer (lignin) (Fengel *et al*., 1984). The percentage of cellulose, hemicellulose and lignin varies with respect to sources (Table 1).

COMPONENTS OF LIGNOCELLULOSIC BIOMASS

Lignin, hemicellulose and cellulose together makes the lignocellulose biomass. The main chain of cellulose is made up of D-glucose subunits joined by β-1,4 glycosidic linkages (Fengel *et al.*, 1984). Cellulose is present in the cell wall of the plants and is the most abundant biomass. Cellulose is 'bundled' into cellulose fibrils or cellulose bundles (fig 1) and are interlinked to each other through van der Waals and hydrogen bonds (Fengel *et al*., 1984). These cellulose fibrils are generally self-contained and have just a weak hydrogen bonding connection (Fengel *et al*., 1984).