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Cellulose Hydrolysis: An Unsolved Problem

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EDITORIAL

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As on today, almost whole world is dependent on fossil fuels as a source of energy. With increase in world's population there are growing concerns about diminishing fossil fuel resources, global warming and environmental pollution; hence there is a need for search of renewable resources to bridge the gap between the supply and demand of energy and chemicals. In this respect for production of biofuels, biomass is the only widespread, abundant, inexpensive and sustainable resource which can be an ideal substitute for fossil resources. The first generation biofuels mainly bioethanol or biodiesel were produced from crops like corn, sugarcane, soybeans, wheat, vegetable oil etc., which can be easily extracted using conventional technology. These crops mainly contains starch, a polymer of D-glucose with α-1,4-glycosidic bonds, soluble in water. Sufficient attention has been paid to use starch to produce fuels and chemicals. But there has always been a competition whether these crops should be used to satisfy food needs or used for biofuel production. Hence, the thought of second generation biofuels came up. Second generation biofuels are also known as advanced biofuels and can supply a larger proportion of global fuel supply sustainably, affordably, and with greater environmental benefits. The goal of second generation biofuel processes is to extend the amount of biofuel that can be produced sustainably by using biomass consisting of lignocellulosic biomass. What separates them from first generation biofuels is the fact that feedstock used in producing second generation biofuels are generally not food crops.

Lignocellulosic biomass mainly consists of 30-50% cellulose, 15-30% hemicelluloses and 15-30% lignin. The problem that second generation biofuel processes are addressing is to extract useful feedstocks from this woody or fibrous biomass, where the useful sugars are locked in cellulose, hemicellulose and lignin. Since cellulose is a major component of lignocelluloses biomass, researchers have now focused their attention towards cellulose hydrolysis for biofuel production. Cellulose is a linear polymer consisting of glucose units linked by β-1,4-glycosidic bonds. Cellulose has highest degree of polymerisation among the lignocelluloses polymers. The number of glucose units in one polymer strand can be 10,000 or higher. The β configuration at the anomeric carbons gives rise to a stretched chain conformation, with hydrogen bonds linking these chains into flat sheets. The linear conformation enables the packing of numerous cellulose strands into crystalline fibres thus giving robustness to the structure. The high molecular weight of cellulose, low flexibility of its polymer chain, inter-, intra-molecular hydrogen bonding and the hydrophobic flat top and bottom surfaces enabling van der Waals interactions between sheets, allow intimate and ordered packing of cellulose making it insoluble in water and most organic solvents. Cellulose is thus not digestible by humans, hence use of cellulose has been limited to textile, paper, plastic and so on. Hence, the essential point is how to degrade this persistent polymer efficiently and selectively to obtain reducing sugars because reducing sugars can be converted into a range of industrially important chemicals including ethanol, 5- hydroxymethylfurfural, liquid fuels and many value added chemicals. Hence these days more attention has been focused on obtaining fuels and value added chemicals from cellulose [1].

Till date, few methods are available for cellulose hydrolysis such as enzyme hydrolysis [2], acid hydrolysis[3], hydrothermal degradation [4], supercritical water hydrolysis [4], heterogeneous solid acid catalyst [5] and few more [6,7] but none of the methods developed are cost effective and can be used for large scale applications. Enzymatic hydrolysis suffer from drawback such as

high cost of enzymes, low reaction rates, needs severe control of enzymes and difficult recovery from the reaction mixture. In acid hydrolysis, high operating cost is involved and also leads to various environmental pollutions. Hydrothermal treatment needs very high temperature and pressure. Supercritical water hydrolysis needs to be carried out in extremely short times (seconds) so as to avoid further decomposition of products. Heterogeneous solid acid catalyst is better but show poor hydrolysis and low yields. Recently, ionic liquids have also been used for cellulose hydrolysis but high cost and high viscosity hampers its commercialization application [8]. Extensively high pressures and high reaction temperatures are needed for hydrolysis of cellulose to reducing sugars and these sugars easily decompose under such harsh conditions.

A simple, inexpensive, high yielding and highly selective green technology for hydrolysis of cellulose to produce biofuels and value added chemicals on commercial scale still remains an unsolved problem and is truly a challenge for researchers working in this field.

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