Biotechnology to improve cellulosic ethanol production from energy crops

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Introduction

Lignocellulose biorefining is a worldwide challenge for chemical and biochemical processes. The bioconversion of renewable materials into chemical and fuel ethanol involves three steps: pretreatment, enzymatic hydrolysis and fermentation. The first step represents the major barrier to commercialization of ethanol due the costs of the pretreatment.

In the recent time, various research initiatives have been developed to find a way of reducing the production costs associated with the production of bioethanol from lignocellulose materials. One of these initiatives is to use classical and precision breeding of feedstocks for preferred characteristics, such as, higher biomass yields per hectare and physico-chemical composition that is amenable to pretreatment-hydrolysis. Any attempt to change the structure matrix of the lignocellulose biomass to make it easier for enzyme attack and reduce the pretreatment cost will be a step forward for the development of large scale, especially if this can be combined with higher biomass yields per hectare, to maximize energy production per land used.

Results and Conclusions

In the present work, the bagasse residues from milling of different varieties of sweet sorghum and sugarcane were evaluated to establish how they respond to diluted acid treatment. The use of bagasse from a variety that is more susceptible to dilute acid pretreatment can reduce input costs to the process by reducing the amount acid, reaction time as well as the energy needed to break the structure of the biomass and release the sugar. In turn, low acid concentration and low temperature can decrease the potential for reduced sugar yield through the formation of sugar degradation products which also inhibit fermentation. Significant improvements in the yield of sugar from hydrolysis of pretreated bagasse, when using preferred varieties were observed. This provides substantial evidence for the use of rational feedstock development to maximise bio-ethanol production per hectare, by using the complete sugarcane or sweet sorghum plant.

Thermo-chemical pretreatment of lignocellulosic biomass also results in the production of toxic by-products resulting of sugar degradation. Furfural and HMF are typically present in the greatest concentrations and inhibit microbial metabolism resulting in decreased ethanol yield and productivity. Therefore, the development of yeast strains tolerant to these by-products is required to enhance ethanol production. In this work, a recombinant xylose-utilizing Saccharomyces cerevisiae strain D5A+ was subjected to one round of random mutagenesis through exposure to the chemical mutagen EMS. Significant improvements in fermentation performance and inhibitor resistance could be achieved by random mutagenesis, selection and evolutionary adaptation of the yeasts.

These represent examples of the application of biotechnologies to significantly improve the efficiency of cellulosic ethanol production from energy crops.

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