Perspective
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Increasing the Efficiency of *Lignocellulose* Breakdown in Industry

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Perspective

Bioconversion of lingo cellulosic biomass to fuels and chemicals represents a new manufacturing paradigm that can help to address the energy, resource and environmental problems of human society. However, the low efficiency and high cost of currently used lingo cellulolytic enzymes hinder their uses in the industrial deconstruction of ligno cellulose. To overcome these challenges, research efforts have been done in engineering the properties, synergy and production of these enzymes. First, the catalytic efficiency, stability and tolerance to inhibitory compounds of lingo cellulolytic enzymes have been improved through enzyme mining and engineering. Second, synergistic actions among different enzyme components were strengthened for the construction of customized enzyme cocktails for degrading specific lingo cellulosic substrates. Third, biological processes for protein synthesis and cell morphogenesis in microorganisms have been engineered to achieve high-level and low-cost production of lingo cellulolytic enzymes. In this review, the relevant progresses and challenges in these fields were summarized. Integrated engineering is proposed to be essential to achieve cost-effective enzymatic deconstruction of lignocellulose in the future.

Lignocellulose biomass is the most abundant organic resource on Earth. The major components of lignocellulose include cellulose, hemicellulose and lignin, which can be enzymatically or chemically degraded into simple sugars and aromatic compounds. The latter compounds can be further converted into various fuels and chemicals, which are expected to replace those produced from petroleum. The plentiful supply and sustainable characteristics of lignocellulose made it the most attractive feedstock in the concept of biomass-based refinery, In addition to the alleviation of resource crisis, the production of lignocellulose-derived fuels and chemicals is also supposed to benefit greenhouse gas mitigation In the past 20 years, the performance of enzymes in lingo cellulosic biomass scarification has been significantly improved, with new-generation cellulose preparations developed by the leading enzyme companies. Using the optimized enzymes, several commercial or pre commercial plants have been built for cellulosic ethanol production. First, improvement of the efficiency of enzymes could reduce their dosage. Second, strain engineering and fermentation optimization could save the cost of enzyme production. Third, on-site enzyme production in the bio refinery plants could minimize the cost of enzyme transport and storage, The discovery of new enzymes and the engineering of currently used enzymes have been successfully used to improve the performances of lingo cellulolytic enzymes. For the discovery approach, sequence-based genome mining and function-based protein separation both provided enzymes with unique properties (see the following subsections). For the engineering approach, directed evolution and rational design were used to improve the properties of many enzymes. In some cases, the two approaches were combined together to effectively generate superior enzyme mutants.

Despite the remarkable progress in the engineering of lingo cellulolytic enzymes and their producing microorganisms, there is still a huge demand of further work to realize large-scale lignocellulose degradation in industry. For most published data in scientific literature, the production levels of ligno cellulolytic enzymes by fungi are lower than the requirements, Wi systematic genetic engineering is expected to produce highly active, robust and well-proportioned lingo cellulolytic enzyme mixtures at high levels. The aid of efficient genome engineering methods systematic genetic engineering is expected to produce highly active, robust and well-proportioned ligno cellulolytic enzyme mixtures at high levels.

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