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NATIONAL RENEWABLE ENERGY LABORATORY

Novel Combination of Enzyme Systems Could Lower Biofuel Costs

Highlights in Science

Two biomass-degrading enzyme systems that work in very different ways are shown to be more effective at releasing plant sugars when used together.

Two natural enzyme systems—free enzymes and cellulosomes—break down cellulose faster if used in combination. The resulting process shows promise for less expensive biofuels. Researchers from the National Renewable Energy Laboratory (NREL) and their partners examined a free-enzyme cocktail of individual plant cell wall active enzymes that work to depolymerize biomass, and an alternative degradation paradigm in which multiple biomass-degrading enzymes, termed the cellulosome, are physically linked by a protein scaffold. This study suggests that two of the most thoroughly studied and distinct paradigms of biomass degradation, namely free enzymes and multi-enzyme cellulosomes, function together in an unexpected way to efficiently deconstruct polysaccharides.

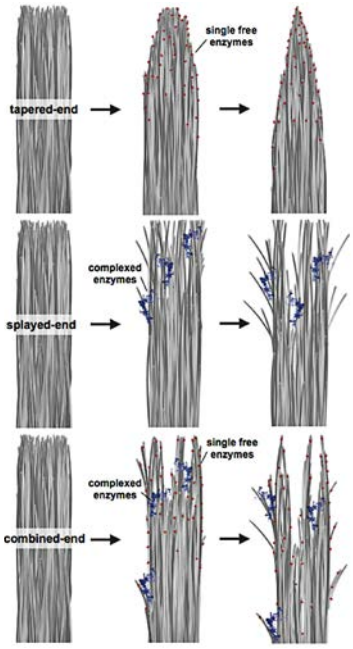

Illustration of the mechanisms by which free enzymes (top) and cellulosomes (middle) differ in their action on cellulose microfibril bundles and act synergistically to degrade cellulose (bottom). Image by Bryon Donohoe, NREL

A large barrier to reaching the goal of producing low-cost biofuels is the high cost of enzyme treatment, a crucial step in turning biomass—switchgrass, energy trees, corn stover, and the like—into liquid fuels. A number of enzymatic strategies are used to degrade polysaccharides in a plant cell wall into sugars for conversion to biofuels. Free enzymes are more active on pretreated biomass; in contrast, cellulosomes are much more active on purified cellulose. In this research, free enzymes and cellulosomes were compared. When the two enzyme systems were combined, changes to the substrate suggest synergistic deconstruction mechanisms.

Transmission electron microscopy revealed evidence that free enzymes and cellulosomes employ different physical mechanisms to degrade cellulose microfibrils. When combined, these systems display dramatic synergistic enzyme activity on cellulose.

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Reference: Resch; M.G.; Donohoe, B.S.; Baker, J.O.; Decker, S.R.; Bayer, E.A.; Beckham, G.T.; Himmel, M.E. (2013). "Fungal Cellulases and Complexed Cellulosomal Enzymes Exhibit Synergistic Mechanisms in Cellulose Deconstruction," *Energy & Environmental Science* (in press).

Key Research Results

Achievement

Researchers have demonstrated that mixing disparate enzyme systems can break down cellulose at the nanometer scale more rapidly and efficiently than one or the other system can alone.

Key Result

Although free cellulases and cellulosomes employ very different physical mechanisms to break down recalcitrant polysaccharides, when combined these systems display dramatic synergistic enzyme activity on cellulose.

Potential Impact

This study indicates new opportunities for mixing free enzymes and cellulosomes in an industrial setting, with the potential for an optimal synergy between two natural mechanisms for biomass deconstruction that further enables cost-effective biofuels production.

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