



Review

Improved lignocellulose conversion to biofuels with thermophilic bacteria and thermostable enzymes

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HIGHLIGHTS

- ▶ Thermophiles are potential candidates for efficient lignocellulose conversion.
- ▶ The limitations of existing lignocellulose conversion processes are discussed.
- ▶ Importance of thermostable enzymes to overcome limitations are discussed.
- ▶ Influence of high temperatures on lignocellulose conversion processes are discussed.

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ABSTRACT

Second-generation feedstock, especially nonfood lignocellulosic biomass is a potential source for biofuel production. Cost-intensive physical, chemical, biological pretreatment operations and slow enzymatic hydrolysis make the overall process of lignocellulosic conversion into biofuels less economical than available fossil fuels. Lignocellulose conversions carried out at $\leq 50^\circ\text{C}$ have several limitations. Therefore, this review focuses on the importance of thermophilic bacteria and thermostable enzymes to overcome the limitations of existing lignocellulosic biomass conversion processes. The influence of high temperatures on various existing lignocellulose conversion processes and those that are under development, including separate hydrolysis and fermentation, simultaneous saccharification and fermentation, and extremophilic consolidated bioprocess are also discussed.

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1. Introduction

The production of first-generation biofuels using food crops such as sugar cane, corn, wheat, and sugar beets competes with the food supply and ultimately result in increased food prices (Havlik et al., 2011). Second-generation biofuels, however, utilize nonfood lignocellulosic agricultural and forestry waste materials. Lignocellulosic materials are mainly composed of lignin, cellulose, and hemicellulose. Lignocellulose (excluding lignin) is an abundant carbohydrate source and has significant potential for conversion into liquid and gaseous biofuels. Cellulose and hemicellulose typically comprise up to two-thirds of the lignocellulosic biomass and are the main sources of sugars for second generation biofuel

production (Hamelinck et al., 2005). To access these cellulosic and hemicellulosic fractions, pretreatments are used prior to enzymatic hydrolysis to open the lignin sheath (Alvira et al., 2010; Hendriks and Zeeman, 2009; Sun and Cheng, 2002). After pretreatment, lignocellulose-deconstructing enzymes, cellulases and hemicellulases, are used to release fermentable sugars. However, existing enzymatic hydrolysis technologies which are carried out at $\leq 50^\circ\text{C}$ exhibit slow enzymatic hydrolysis rates, generate low yields of sugars from lignocellulose (often incomplete hydrolysis), require high dosages of enzymes, and are prone to microbial contamination problems. It has been suggested that these limitations could be overcome by using thermophilic bacteria and thermostable enzymes (Yeoman et al., 2010; Viikari et al., 2007). Therefore this review focuses on thermostable lignocellulose-deconstruction enzymes from thermophilic bacteria and their applications in biofuel production.

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