Synegistic degradation of biomass with xylanase and cellulase by improving xylanase catalytic activity and thermostability using module replacement

Abstract

Background: Xylanase is one of the most extensively used biocatalysts in biomass degradation. However, the low catalytic efficiency and poor thermostability limit their applications. Improving properties of xylanase and synergistically degrading lignocellulosic biomass with cellulase is of considerable significance for bioenergy.

Results: By substituting modules, the catalytic performance and thermostability of a GH10 xylanase XylE were improved. Among 10 hybrid enzymes obtained, seven showed xylanase activity. Substitution of modules M3, M6, M9, and their combinations improved the catalytic efficiency (by 2.4 to 4.0-fold) and the specific activity (by 1.2 to 3.3-fold). Hybrids XylE-M3, XylE-M3/M6, XylE-M3/M9, and XylE-M3/M6/M9 showed enhanced thermostability (increases in the T_{50} (3.0-4.7 °C), T_{m} (1.1-4.7 °C), and extended $t_{1/2}$ (1.8-2.3 h). In addition, the synergistic effect of mutant xylanases and cellulase on the degradation of mulberry bark showed that the experimental group with the most synergistic effect was both XylE-M3/M6 and cellulase addition, which the degree of synergy reached 1.3 and the reducing sugar production and dry matter reduction increased by 148% and 185% compared with the cellulase addition only.

Conclusions: This study provides a successful strategy to improve enzymes catalytic properties and thermostability and identified several xylanase candidates for bioenergy and biorefinery application. Synergistic degradation experiment elucidates a possible mechanism for cellulase inhibition by xylan and xylo-oligomers.

Keywords: GH10 xylanase; catalytic efficiency; thermostability; module substitution; biomass degradation