Alkaline Pretreatment of Genetically-Engineered Switchgrass for Improved Carbohydrates Conversion Efficiency

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Introduction

- Switchgrass as energy crop for fuel ethanol production
  - Native to North America
  - High biomass yield: 15-25 dry tons / hectare
  - Low agricultural inputs requirement
  - Environmentally friendly

- Obstacles of carbohydrates conversion for switchgrass
  - High lignin content (20%, dry weight) in conventional switchgrass
  - High cellulose crystallinity for conventional switchgrass

- Approaches to overcome the aforementioned obstacles
  - Genetically engineer switchgrass to reduce lignin content
  - Alkaline pretreatment of transgenic switchgrass to further remove lignin and disrupt the recalcitrant biomass structure for high sugar yield

Objectives

- Examine differences between conventional and transgenic switchgrass regarding chemical composition and morphological features
- Identify the potential improvement of sugar production from alkaline-pretreated switchgrass using transgenic plants

Materials and Methods

Conventional and Transgenic Switchgrass

Oven Dry at 50 °C and Size Reduction to 2 mm
Alkaline Pretreatment at 121 °C
0.5% NaOH, 15 min
1% NaOH, 30 min
2% NaOH, 60 min

Composition Analysis and Morphological Characterization

Enzymatic Hydrolysis at 50 °C for 72 hours pH of 4.8
Cellic CTec 2: 40%
Cellic HTec 2: 6%

Results

Biomass compositional changes after genetic modification
- Total lignin content reduction: up to 7% in leaf and 16% in stem

Sugar production from NaOH-pretreated switchgrass using transgenic plants
- Improved sugar yield by up to 22%

Conclusions

- Genetic modification of lignin biosynthesis can reduce the lignin content in switchgrass by up to 16%.
- There was no significant difference in the cross-section between conventional and transgenic untreated switchgrass, but transgenic plants has slightly smoother surface.
- Sodium hydroxide pretreatment can render smoother surface and looser inner structure for switchgrass.
- Sugar production from NaOH-pretreated switchgrass can be significantly improved using transgenic plants.

Future Directions

- Examine other conditions of alkaline pretreatment of transgenic switchgrass to maximize sugar production
- Investigate the mechanism of alkaline pretreatment using Raman Spectroscopy
- Conduct sensitivity analysis of experimental data for process simulation of the overall switchgrass-to-ethanol conversion

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