First-of-a-kind study of thermophilic CBP with cotreatment

U.S. DEPARTMENT OF ENERGY | Office of Science

Background

Milling during lignocellulosic fermentation (or "cotreatment") is an alternative to thermochemical pretreatment to enhance biological solubilization of lignocellulose.

Approach

Carbohydrate solubilization was measured in consolidated bioprocessing with *Clostridium thermocellum* with cotreatment or with hydrothermal pretreatment.

Outcome

- Total fractional carbohydrate solubilization achieved after fermentation of senescent switchgrass by *C. thermocellum* for 5 days was 0.45 without co-treatment or pretreatment, 0.81 with hydrothermal pretreatment (200ºC, 15 minutes, severity 4.2 – not shown), and 0.88 with co-treatment with ball milling (Figure 1). This corresponded with fermentation gas production (mostly CO_2).
- Milling had little effect on soluble substrate fermentation by *Clostridium thermocellum* whereas yeast fermentation was completely arrested (likely due to the impact of milling shear forces on the yeast and not the bacteria).
- Characterization of residual solids using molecular beam mass spectrometry and solid-state nuclear magnetic resonance spectroscopy indicated little change in lignin structure following CBP with cotreatment, and substantially larger changes for CBP following hydrothermal pretreatment (Figure 2).

Figure 1. CBP and Cotreatment

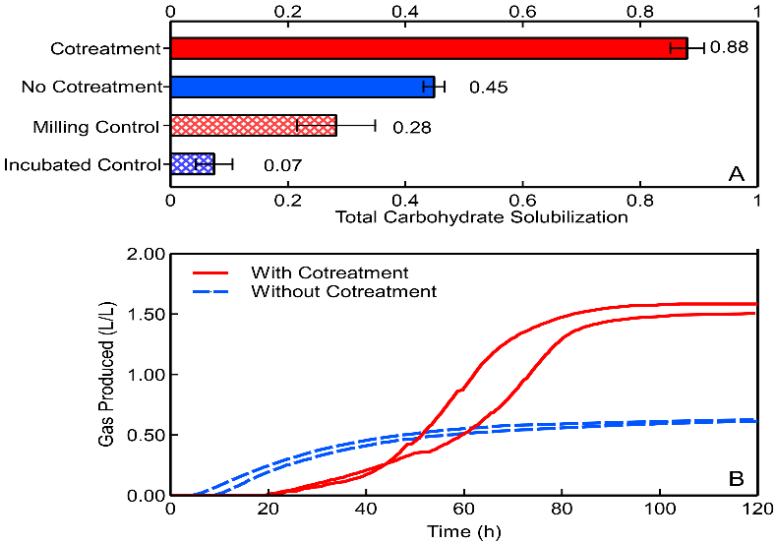
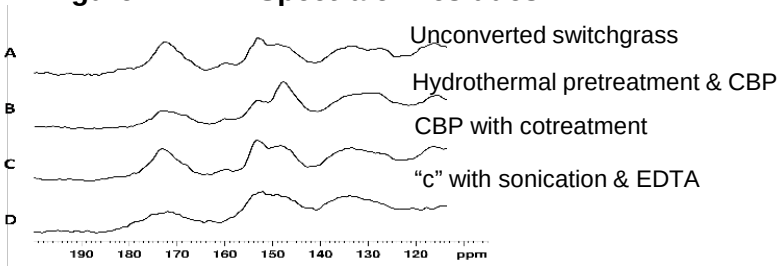


Figure 2. NMR Spectra of Residues



Significance

- High carbohydrate solubilization is demonstrated without thermochemical pretreatment and added saccharolytic enzymes
- *C. thermocellum* appears able to attack all the major linkages in cellulosic biomass provided that these linkages are accessible.
- The ability of *C. thermocellum* to withstand high intensity milling supports the feasibility of cotreatment.
- Less modified lignin may foster production of value-added coproducts.

Balch, ML, EK Holwerda, M Davis, R Sykes, R Happ, R. Kumar, CE Wyman, and LR Lynd. "Lignocellulose fermentation and residual solids characterization for senescent switchgrass fermentation by Clostridium thermocellum in the presence and absence of continuous in-situ ball-milling," *Energy Environ. Sci.* 2017. doi: 10.1039/C6EE03748H

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