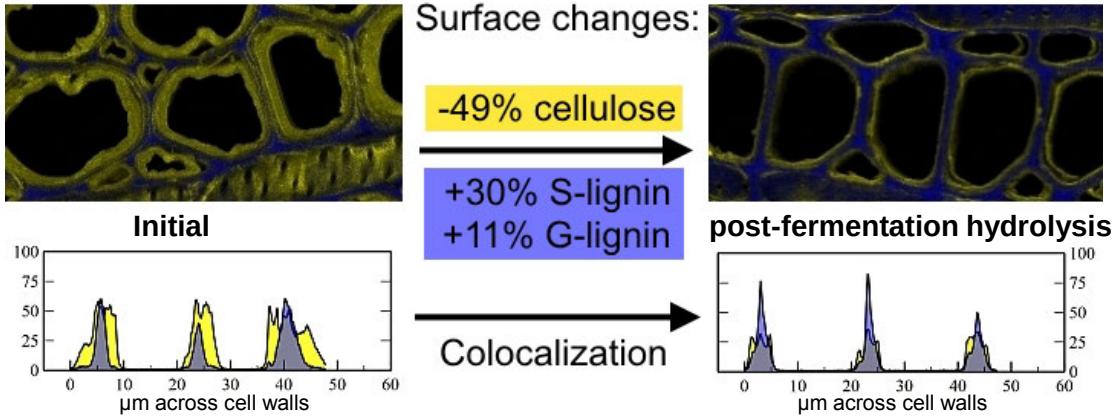
New insights on recalcitrance from lignin inhibition of microbial deconstruction

U.S. DEPARTMENT OF ENERGY | Office of Science

Background

- Microbial solubilization of biomass selectively targets the carbohydrates.
- *Clostridium thermocellum*, a highly effective cellulolytic microbe, can hydrolyze ~93% of 100gL^{-1} pure cellulose.
- The microbe solubilizes only partially hydrolyzes cellulose in untreated energy crops (~35% of in hard woods and ~60% in senesced switchgrass).

Microbial hydrolysis changes poplar cell wall surfaces



Cellulose (yellow) decreases and lignin (blue or gray) becomes more prominent

Approach

- The post-fermentation surface chemistry of *Populus* cell walls was investigated to quantify recalcitrance to microbial hydrolysis.
- Techniques used were “quantitative fluorescence colocalization analysis” in Confocal Laser Scanning Microscopy and “surface chemical imaging” in Time-of-Flight Secondary Ion Mass Spectrometry.

Outcomes

- Post-fermentation biomass had 28% reduced cellulose and became non-productive towards further hydrolysis.
- In post-fermentation cell walls, colocalization of cellulose and lignin increased.
- The surface composition of the tissue showed 49% reduced cellulose and an increase of 30% and 11% in S-lignin and G-lignin, respectively.

Significance

- Quantitative evidence is provided for the cause of feedstock recalcitrance:
  - depletion of surface carbohydrate increases lignin exposure which leads to inhibition of enzymatic activity, while the bulk residual biomass retains significant undigested sugar content.
- Limited hydrolysis is not caused by inhibitory hydrolyzed sugars nor fermentation products (i.e., ethanol).

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Dumitrache et al., “Cellulose and lignin colocalization at the plant cell wall surface limits microbial hydrolysis of *Populus* biomass,” *Green Chemistry*, 2017 (in press). DOI: 10.1039/c7gc00346c