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Transforming ENERGY

Genetic Targets for Overcoming Biomass Recalcitrance

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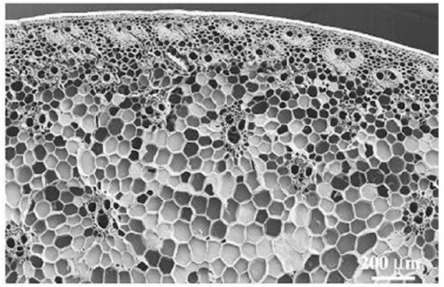
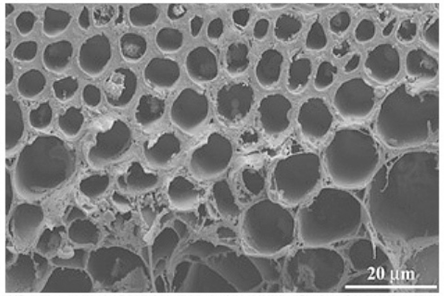
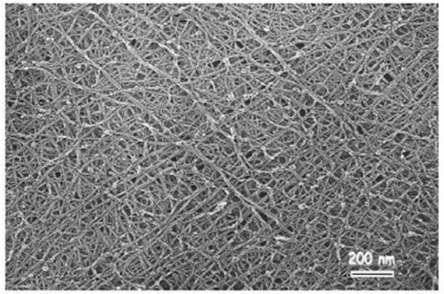
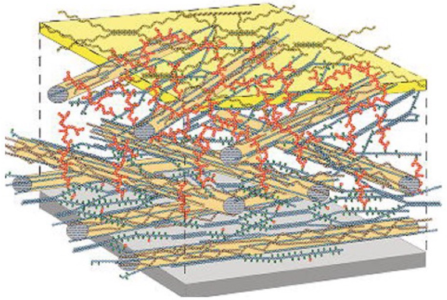
We define recalcitrance as those features of biomass which disproportionately increase energy requirements in conversion processes, increase the cost and complexity of operations in the biorefinery, and/or reduce the recovery of biomass carbon into desired products

Recalcitrance occurs at several scales of biomass









At organ scale, proportions of secondary walled cells and tissue anatomy impact enzymatic hydrolysis:

- Grass nodes are more recalcitrant than internodes

At cellular scale, lignin-xylan-pectin interactions glue fiber cells together:

- High S-lignin reduces cell adhesion compared to wild type
- Expression of a pectin-degrading enzyme in transgenic poplar improves cell separation for biomass comminution

Lignin-cellulose interactions at molecular scale impact enzyme access to substrates:

- Genetic modification of lignin composition enhances saccharification yields

Woody biomass is compositionally different from biomass of grasses and require different genetic approaches:

- *Availability of genetic models and tools varies for different species*

Sorghum is a genetically tractable biomass crop

A genetic variant in leaf angle improves biomass yields by 10%

Truong, McCormick, Rooney & Mullet (2015) Genetics 201: 1229-1238

- Drought-tolerant annual diploid species, amenable to genetic transformation
- 40,000 accessions capture natural genetic diversity in sorghum
- 400 genetically mapped bioenergy sorghum lines for gene discovery
- Engineered novel genetic circuits for high-value products
- Existing mutants and engineered lines with high sugar/high oil accumulation in stalks

Genetic improvements have been made to:

- Impart photoperiod insensitivity and improve yields
- Improve compositional quality of sugars, aromatics, oils, and other products
- Alter cell wall structure to reduce recalcitrance
- Improve soil sustainability through better nitrogen-use efficiency, and root system biomass

Feedstock optimization requires a systems approach

Co-optimization strategy enables a pipeline of germplasm improvement for seed companies, growers, and conversion process improvements for project developers

- Existing feedstock variants can be assessed across dimensions of yield, performance in conversion processes, and sustainability
- Recalcitrance factors that emerge in the value chain become new traits for selection
- Feedback loops inform targets for genetic improvement of feedstock and of conversion processes