120. Introducing readily cleavable bonds into the lignin backbone: The Zip-Lignin™ Strategy

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Project Goals: To provide plants with the necessary pathways to produce monolignol ferulate conjugates and export them to the cell wall where they introduce readily cleavable ester linkages (‘zips’) into the lignin polymer backbone in ways that significantly improve biomass processing energetics.

Lignin is a complex and irregular phenolic polymer that fortifies plant cell walls, and is responsible for the majority of the recalcitrance to industrial processing of plant biomass. The biosynthesis of lignin has been found to tolerate a large variety of perturbations to the lignin monomer pool. We have utilized this plasticity to incorporate ester linkages into the lignin polymer backbone by introducing a FERULOYL-CoA MONOLIGNOL TRANSFERASE (FMT) gene fused to a xylem-specific promoter into poplar trees. The FMT enzyme produces monolignol ferulate conjugates that integrally incorporate into the lignin polymer backbone. Under mild alkaline pretreatment conditions the ester bonds readily cleave resulting in an improved digestibility for the FMT-poplar over wild-type poplar. With improved methods recently developed, we have found that many plants seem to naturally incorporate low levels of these monolignol ferulate conjugates. In a screening of over 30 plant species, mainly cash crops, we found evidence for the conjugates in grain crops (corn, sorghum, rice, wheat) as well as some hardwoods (poplar, aspen, eucalyptus, balsa), but not in softwoods (cedar or spruce). The finding of such naturally occurring zip-monomers opens up new opportunities for engineering or breeding crop plants with cell walls that are better designed for deconstruction.

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