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**Using coproducts from lignin to increase value from biorefineries**

An analysis of the full biorefinery system, from field to liquid fuels and coproducts, identifies key parameters for process improvement.

**The Science**

In this highly collaborative Great Lakes Bioenergy Research Center (GLBRC) study, researchers in plant biology, lignin chemistry, microbial fermentation, and technoeconomic modeling tackled the question of how to improve the economics of liquid fuel biorefineries. The team genetically engineered plants to make higher levels of hydroxycinnamic acids, which are high-value, naturally produced chemicals bound to the lignin polymer in plants. The resulting plant material was processed using lab-scale alkaline pretreatment to release the acids and allow the remaining sugar mixture to be used for liquid fuel production. Technoeconomic analysis of this entire biorefinery system was performed to identify key parameters for process improvement.

**The Impact**

Valuable coproducts are expected to be an important contributor to the economics of lignocellulosic biorefineries. By assessing biomass pretreatment and recovery of two high-value hydroxycinnamic acids, GLBRC researchers discovered that isolating and purifying these two chemicals as coproducts from a biorefinery was not cost effective; rather, an economically viable coproduct strategy would require channeling coproducts to a single useful product. This knowledge will guide decisions ranging from plant feedstock engineering, to pretreatment, and to downstream biological funneling efforts to produce a single coproduct from a liquid fuel-producing biorefinery.

**Summary**

The production of high-value coproducts could add revenue to, and thereby improve the overall economics of, lignocellulosic biorefinery operations. In this study, GLBRC researchers investigated the potential benefit of increasing levels of chemicals bound to lignin in grass crops, specifically the hydroxycinnamic acids *p*‐coumaric acid (*p*CA) and ferulic acid (FA). The level of lignin‐bound *p*CA in *Zea mays* was boosted by the alteration of *p*‐coumaroyl‐CoA monolignol transferase expression. Data from lab‐scale alkaline pretreatment of the modified biomass were used to conduct a baseline technoeconomic analysis to determine where to direct future research efforts to couple plant design to biomass utilization processes. With the relevant genes identified, the scientists concluded that future plant engineering efforts should focus on strategies that ramp up accumulation of a single hydroxycinnamate (*p*CA or FA) predominantly and suppress that of the other. Technoeconomic analysis indicates that target extraction titers of one hydroxycinnamic acid need to be >50 g kg−1 biomass — at least five times higher than observed titers for the impure *p*CA/FA product mixture from wild‐type maize. The resulting technical challenge for process engineers is to develop a viable coproduct isolation process that reduces costs by more than 80%. The knowledge gained from this study will guide decision making at all steps of the biorefinery, from plant feedstock engineering to pretreatment strategies and downstream processes.

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**Publications**

S. D. Karlen *et al.* “Assessing the viability of recovery hydroxycinnamic acids from lignocellulosic biorefinery alkaline pretreatment waste streams.” *ChemSusChem* (2020) [DOI: 10.1002/cssc.201903345]

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