A Strategy to Understand and Improve Microbial Lignin Bioconversion through Solubilization and Separation of the Constituents of the Biopolymer

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Project Goals: We are seeking to enhance the depolymerization and conversion of lignin into advanced biofuels and high-value co-products by developing strategies and analytical tools for understanding the factors responsible for the recalcitrance of this abundant biopolymer. Lignin valorization is an emerging part of Joint Bioenergy Institute's (JBEI) mission to convert lignocellulosic plant biomass into renewable biofuels and biochemicals. The focus of this study is to gain a fundamental understanding of physico-chemical properties that are the origins of the recalcitrance of lignin, and to then use this knowledge to biologically depolymerize the macromolecule. This study complements the extensive research and technology development for deconstructing and converting the polysaccharide component of plant biomass into next generation biofuels that has been developed at JBEI.

Abstract

Lignin depolymerization and conversion to high-value renewable bio-products (valorization) have gained enormous attention in recent years because of the abundance and high energy content of these naturally derived aromatics macromolecules[1]. Lignin valorization is generally limited by the recalcitrance and complexity of the heterogeneous polyphenolic component of plant cell wall[2] and inadequate analytical tools and strategies for rapid and routine characterization of the macro-molecule. Lignin recalcitrance is often attributed to complex C-C or C-O ether bonds[3] that irregularly linked it primary *p*-hydrophenyl (H), guaiacyl (G) and syringyl (S) moieties. However, our studies indicated that physical interactions between the amphiphilic lignin molecules significantly influence the recalcitrance of the macromolecule to chemical and biological depolymerization. Therefore, this study focused on developing strategy for reducing the physical complexity of 'non-derivatized' lignin extracts such as Klason and organosolv lignin extracts. We report the deconvolution and separation of the primary components of Klason lignin from switchgrass by manipulating the amphiphilic properties of the lignin moieties at ambient temperature. Our result revealed that the lignin extract consists of 5 – 8 distinct types of moieties with varying solubility in water at neutral pH. These distinct lignin moieties were also observed in organosolv lignin and lignin extracts from ionic-lignin pretreated and enzymatically saccharified plant biomass. Approximately 80 – 90% of the total lignin in Klason lignin extract from switchgrass was soluble in alkaline solution. The residual alkali-

insoluble lignin moieties consist primarily of very high molecular weight aromatic polymers. A significant fraction of the alkali-soluble lignin fractions (30 – 50%) consist of polydispersed and water-soluble moieties (PW-L02) ranging from ≤ 1 kDa to ≥100 kDa. The PW-L02 fraction was used as substrate to characterize the ability of microbial species to utilize polymeric lignin.

References

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