

## STABILIZATION WITH FORMALDEHYDE FACILITATES THE HIGH-YIELD PRODUCTION OF MONOMERS FROM LIGNIN DURING INTEGRATED BIOMASS DEPOLYMERIZATION

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Practical, high-yield lignin depolymerization methods could greatly increase biorefinery productivity and profitability. However, development of these methods is limited by the presence of inter-unit carbon-carbon bonds within native lignin, and further by formation of such linkages during lignin extraction. We report that adding formaldehyde during biomass pretreatment produces a soluble lignin fraction that can be converted to guaiacyl and syringyl monomers at near-theoretical yields during subsequent hydrogenolysis (48-78% of native lignin, 55-99% from extracted lignin). We achieved the highest yields using a high-syringyl transgenic poplar with low levels of carbon-carbon linked units. These yields were 3-7 times those obtained without formaldehyde, which prevented lignin condensation primarily by forming 1,3-dioxane structures with lignin side-chain hydroxyl groups. By depolymerizing cellulose, hemicelluloses, and lignin separately, overall monomer yields between 76 and 90% were achieved for these three major biomass fractions. Recovery of an isolated lignin fraction that is soluble in an organic solvent and can produce high monomer yields could facilitate continuous lignin processing and the development of heterogeneous catalysts for lignin conversion.