COMPLETE CONVERSION OF BIOMASS TO SUGARS AND LIGNIN MONOMERS USING GAMMA-VALEROLACTONE AS A SOLVENT

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Widespread production of biomass-derived fuels and chemicals requires cost-effective processes for breaking down cellulose, hemicellulose and lignin into their constituent monomers. Gamma-valerolactone (GVL) is a molecule that can be produced from biomass itself and, when used as a solvent, promotes thermocatalytic saccharification of polysaccharides by complete solubilization of biomass including the lignin fraction. Soluble carbohydrates can be produced at high yields (70-90%) from corn stover, hardwood and softwood in a solvent mixture of GVL, water, and dilute acid (0.05 wt% H_2SO_4). Complete lignin solubilization and increased catalytic activity of the acid due to solvent effects could help explain improved biomass deconstruction in GVL. Furthermore, the carbohydrates can be recovered and concentrated (up to 127 g/L) in an aqueous solution by adding CO_2 to form a CO_2-expanded GVL phase no longer miscible with water. This strategy is well suited for catalytic upgrading to furans or fermentative upgrading to ethanol at high titers and near theoretical yield.

In parallel, the solubilized lignin stream can be recovered at high yields (>70% of the original lignin) by precipitation in water. Analysis of the isolated lignin by NMR demonstrated that its chemical properties remained remarkably similar to those of native lignin or enzymatically isolated lignin despite the high temperatures and acid used during processing. Because of this, our isolated corn stover lignin is an interesting candidate for hydrogenolysis over noble metal catalysts. Using Ru/C in the presence of phosphoric acid, this lignin was converted to identifiable heptane-soluble lignin monomers at carbon yields of up to 38%. Adding small quantities of methanol to the reaction stabilized intermediates by forming methyl-esters, further increasing carbon yields up to 48%. These results suggest that biomass processing in GVL could enable the complete and integrated conversion of all three biomass fractions into useful chemical and biological intermediates.

References

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