

Liquid-phase catalytic conversion of lignocellulosic biomass to fuels and chemicals

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Biomass is an important renewable source of carbon for the sustainable production of fuels, chemicals, and materials. We will present results from our recent work on liquid-phase catalytic processing of lignocellulosic biomass, with an emphasis on the synthesis of new catalytic materials and the elucidation of solvent effects for these processes. We will show aqueous-phase processing can be carried out over bimetallic catalysts (e.g. RhRe, RhMo, PtMo) to achieve selective production of α,ω -diols from biomass-derived reactants. We will show that the active sites on these bimetallic catalysts are bifunctional in nature, where the more reducible metal (Rh, Pt) catalyzes hydrogenation/dehydrogenation processes, and the more oxophilic metal (Re, Mo) provides sites that facilitate acid-catalyzed reactions. We will then present strategies for the catalytic conversion of the C₅ and C₆ sugars present in hemicellulose and cellulose, respectively, to produce gamma-valerolactone (GVL). We will present a processing approach that uses GVL as a solvent to convert simultaneously the C₅ and C₆ sugars in biomass, thereby simplifying separation steps, because GVL is one of the reaction products. We will demonstrate that we can produce soluble carbohydrates from corn stover, hardwood and softwood at high yields (80-90%) in a solvent consisting of biomass-derived GVL, water, and dilute acid (0.005 M). We will show that these carbohydrates can be recovered and concentrated (up to 130 g/L) in an aqueous phase by extraction of GVL using CO₂. We will then present results from reaction kinetics studies to quantify the effects of polar aprotic organic solvents on reaction rates and selectivities of acid-catalyzed reactions of relevance for biomass conversion (e.g., xylose dehydration to furfural). We will suggest that the aprotic organic solvent affects the stabilization of the acidic proton relative to protonated transition states, leading to accelerated reaction rates for these acid-catalyzed biomass conversion reactions.