

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

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Environmental and political issues created by our dependence on fossil fuels, such as global warming and national security, combined with diminishing petroleum resources are causing society to search for new renewable sources of energy and chemicals, and an important sustainable source of organic fuels, chemicals and materials is plant biomass. We will show aqueous-phase processing can be carried out over bimetallic catalysts (e.g., RhRe, RhMo, PtMo) to achieve selective production of **fuels** from biomass-derived reactants. We will show that the active sites on these bimetallic catalysts are bi-functional 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 C<sub>5</sub> and C<sub>6</sub> sugars present in hemi-cellulose and cellulose, respectively, to produce gamma-valerolactone (GVL). We will present a processing approach that uses GVL as a solvent to convert simultaneously the C<sub>5</sub> and C<sub>6</sub> sugars in biomass, thereby simplifying separation steps, because GVL is one of the reaction products. Additionally, GVL solubilizes the degradation products typically formed during biomass deconstruction, and this approach can thus be implemented using continuous flow reactors. 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 CO<sub>2</sub>. These yields and sugar concentrations are comparable to those obtained using multiple steps and/or high-cost chemicals or bio-catalysts, such as hydrolysis in concentrated mineral acids, pretreatment and enzymatic hydrolysis, or ionic liquid hydrolysis. 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 the protonated transition states, leading to accelerated reaction rates for these acid-catalyzed biomass conversion reactions.