Hybrid Biochemical/Catalytic Conversion of Biomass to Butene

Praveen Vadlani (Grain Science) and Keith Hohn (Chemical Engineering)

Biofuels from agricultural resources have evolved as alternatives to the current transportation fuels due to fluctuations in global oil prices, recent advances in technologies, and increased environmental awareness. U.S. biomass resources could provide approximately 1.3 billion dry tons of feedstock for biofuels, which would eventually meet about 40% of the annual U.S. fuel demand. However, current commercial biofuels (ethanol and biodiesel) can not be used as direct replacements for aviation and military fuels. Rather, biomass must be converted to hydrocarbons, which is a challenging process because of the large chemical differences between biomass components and hydrocarbons.

Our hypothesis is that a combined biochemical/thermocatalytic process will produce hydrocarbons from biomass with high yield and promising economics. We propose to use biochemical routes to convert biomass-derived sugars to 2,3-butanediol (2,3-BD), and then apply heterogeneous catalysis to first dehydrate 2,3-BD to methyl ethyl ketone and then dehydrate and hydrogenate methyl ethyl ketone to butene. Butene could then be oligomerized to liquid hydrocarbon fuels. This route was chosen because 2,3-BD production *via* microbial fermentation uses all sugars (glucose and xylose) derived from biomass and results in high product concentration and productivity, fermentation of biomass-derived sugars to 2,3-BD gives higher yields than other fermentation routes, and the chosen catalytic reactions are capable of high selectivities and high reaction rates.

Research into the microbial production of 2,3-BD will focus on developing robust modified *Klebsiella oxytoca* and *Bacillus Polymyxa* microbial strains that will utilize biomass-derived glucose and xylose for high 2,3-BD yield and productivity at fermenter level. Research on catalytic processes will focus on two reactons: 2,3-BD dehydration to methyl ethyl ketone and methyl ethyl ketone dehydration/hydrogenation to butene. 2,3-BD dehydration will be studied on a variety of solid acid catalysts to determine the effect of acid site strength and density. In addition, deactivation of the catalysts by fermentation broth and its components will be studied. Bifunctional catalysts containing both metal and acid sites will be studied for direct conversion of methyl ethyl ketone to butene in the presence of hydrogen. The impact of temperature, hydrogen partial pressure, and catalyst composition will be evaluated.