Catalytic Biomass Pyrolysis for Advanced Biofuels and Bio-products: Fundamentals to Pilot-scale

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ABSTRACT

Over the past 10 years we have been investigating catalytic biomass pyrolysis for producing a hydrocarbon-rich bio-crude intermediate that can be upgraded into biofuels and bio-products. The chemistry of biomass pyrolysis is manipulated by the catalyst and by controlling the pyrolysis temperature, reactor atmosphere, vapor residence time, and biomass-to-catalyst ratio.

Our flexible and robust experimental facilities are capable of investigating biomass thermochemical conversion with real biomass from the bench-top to the pilot-scale. Fundamental biomass pyrolysis studies are conducted with a micro-pyrolyzer coupled with a gas chromatograph for quickly performing complex studies on virtually any feedstock (liquid, gas and solid) with or without catalysts in various atmospheres (e.g., helium, hydrogen, air) over a wide range of temperatures and pressures with quantitative characterization of pyrolysis products. With this fundamental understanding, we have scaled the technology up from a 2.5” diameter bubbling fluidized bed reactor to a circulating fluidized bed unit with a nominal throughput of one ton per day (1 TPD). Parametric studies have been performed to understand the effects of operating conditions (mainly temperature) on bio-crude yield and oxygen content. Extensive online analytical sampling and offline characterization of all process streams to close material balances and provide reliable chemistry and engineering data.

A novel catalyst has been discovered that effectively produces a low oxygen-content, thermally stable bio-crude intermediate. Conventional hydrotreating technology is being adapted to upgrade this bio-crude. Long-term performance (activity and stability) of hydrotreating catalysts selected specifically for bio-crude upgrading have been tested. Results suggest that the hydrotreating performance is affected not only by the bulk oxygen content but also the kind of oxygen species that remain in the bio-crude intermediate.

With improved bio-crude thermal stability and quality, a comprehensive separation strategy is also being developed to efficiently and economically recover valuable methoxyphenols from bio-crude. These chemical building blocks can be used to demonstrate that bioproducts could enable cost-effective production of biofuels via integrated catalytic biomass pyrolysis and hydrotreating.
BIO-SKETCH

Dr. David C. Dayton is a RTI Senior Fellow (Chemistry) and the Director of the Biofuels Program in RTI International’s Energy Technology Division with over 25 years of project management and research experience in biomass thermochemical conversion R&D projects involving biomass combustion, gasification, and pyrolysis. His current research focuses on alternative fuels research, particularly catalytic biomass pyrolysis technology development, synthesis gas conversion, cleanup, and conditioning, and experimental programs relating to biomass thermochemical conversion for biofuel production. These R&D activities are focused on expanding integrated biorefinery technology development activities for advanced biofuel production.

Dr. Dayton came to RTI in July 2007 following 14 years at the National Renewable Energy Laboratory as the technical leader of the Thermochemical Platform where he managed biomass thermochemical conversion projects for the U.S. Department of Energy. He was a postdoctoral research associate at the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD from 1991-1993. He received his Ph.D. in Physical Chemistry from the University of North Carolina, Chapel Hill, NC in 1990 and a B.S. in Chemistry from Dickinson College in Carlisle, PA in 1985.

Dr. Dayton has published over 70 technical papers, book chapters, and technical reports.