PROJECT FACTS

UNIVERSITY OF KENTUCKY CENTER FOR APPLIED ENERGY RESEARCH

BIOFUELS & ENVIRONMENTAL CATALYSIS

PARTICIPANTS

Department of Biosystems & Agricultural Engineering, University of Kentucky

University of Kentucky Center for Applied Energy Research

SPONSORS

Kentucky Rural Energy Consortium (KREC)

Kentucky Office of Energy Policy (KOEP)

PROJECT VALUE

KREC: $101,083
KOEP: $27,302

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Novel Catalytic Approaches for Bio-Crude Upgrading

Biomass conversion to liquid products has the potential to reduce domestic dependence on imported petroleum crude used for the production of fuels and industrial chemicals. Biomass can be converted into fuels and chemicals indirectly (by gasification to syngas followed by catalytic conversion to liquid fuels) or directly to a liquid product. Direct thermochemical conversion processes include pyrolysis, high-pressure liquefaction, and solvolysis. The crude bio-oils afforded by these processes are chemically complex and are typified by high oxygen content. As a consequence, crude bio-oils exhibit instability with respect to condensation reactions, which lead to the formation of heavier compounds during prolonged storage. In this context, we are studying new approaches for catalyst-assisted stabilization of crude biomass-derived pyrolysis oils, for the ultimate production of fuels and high value chemicals.

To date, the upgrading of bio-oils has been achieved using cracking or hydrotreating. Given that hydrotreating requires large volumes of hydrogen, which significantly impairs process economics, cracking represents a more economically attractive option. However, difficulties encountered in the use of acid cracking catalysts such as H-ZSM-5 include (i) relatively high yields of (low value) gaseous hydrocarbons, and (ii) the occurrence of coke formation, resulting in rapid catalyst deactivation (as a consequence of the high polymerization activity of bio-derived pyrolysis oils).

In view of these deficiencies, we are developing alternative concepts aimed at catalytic deoxygenation of bio-oil, involving (i) mild cracking over base catalysts, and (ii) metal-oxide catalyzed deoxygenation based on oxygen transfer to a reducing agent (carbon monoxide). This will enable crude bio-oil to be stabilized with respect to the retrograde reactions that would otherwise occur during storage and shipping, thereby facilitating localized production and stabilization of bio-oil. In this way, biomass can be converted to stabilized bio-oil on the farm, eliminating expensive biomass transportation costs. Subsequent upgrading and product separation could then be accomplished using conventional means at a centralized refinery.

In this project, which is being performed jointly with the UK Department of Biosystems and Agricultural Engineering, model bio-oils are being upgraded using the above catalytic approaches and then subjected to detailed analysis in order to assess the extent of deoxygenation and product slate. The most promising catalyst systems will then be tested with a softwood-derived fast pyrolysis oil.