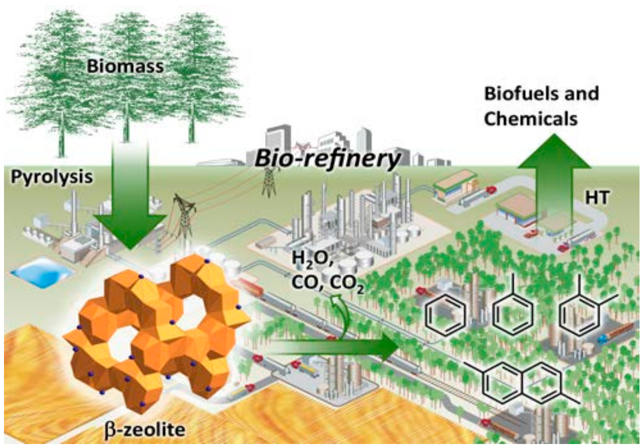
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Improving Catalyst Efficiency in Bio-Based Hydrocarbon Fuels

Highlights in Science

New study determines the effect of catalyst structure on product yields and coking during vapor phase upgrading of biomass pyrolysis products.



This study investigates the role of β-zeolite acid site density on hydrocarbon and coke yields. Image by Al Hicks and Ray David, NREL

Converting biomass, an abundant and renewable resource, into liquid transportation fuels has attracted significant attention because of depleting fossil fuel reserves and associated environmental concerns. In the quest for sustainable and eco-friendly fuel alternatives, much research is focusing on improving the properties of bio-oil. Scientists at the National Renewable Energy Laboratory (NREL) studied the structure and properties of zeolites (widely used catalysts that accelerate chemical reactions and improve the effectiveness of the process) and investigated upgrading biomass pyrolysis vapors to form hydrocarbon fuels and chemicals that use catalysts with varying concentrations of acid sites. The results showed that greater separation of acid sites improves the efficiency of catalysts for producing significant amounts of hydrocarbon fuels and chemicals. It also reduces coke formation.

In this study of pine pyrolysis products, β-zeolites with a lower silica-to-alumina ratio (SAR)—or more acid sites—primarily produced aromatic hydrocarbons and olefins with no detectable oxygen-containing species. This is noteworthy because bio-oil that has not been upgraded has limited applications, as oxygenated species are present that are derived from the cellulose, hemicellulose, and lignin. The oxygenated products found in catalysts with a high SAR give rise to bio-oil with high acidity, high viscosity, low heating value, immiscibility with hydrocarbons, and aging during storage. These are significant technical and economic barriers that could slow or prevent commercial deployment of bio-oil in the transportation fuels industry.

The discovery that the number of acid sites in catalysts affects the amount and quality of the resulting bio-oil will set the foundation for future work on enhancing catalyst efficiency. More effective catalysts will enable the production of bio-oil with improved properties that can be upgraded to feedstocks and/or blendstocks for further refining to finished fuels.

Technical Contact: Calvin Mukarakate, *calvin.mukarakate@nrel.gov*

Reference: Mukarakate, C., et al. (2014). "Upgrading biomass pyrolysis vapors over β-zeolites: role of silica-to-alumina ratio." *Green Chemistry* (16:12); pp. 4891-4905. NREL/JA-5100-63211. *http://dx.doi.org/10.1039/C4GC01425A*

Key Research Results

Achievement

This study explored the effects of concentrated active sites on catalyst deactivation while biomass pyrolysis products are being upgraded during the vapor phase to form hydrocarbon fuels and chemicals. During this process, NREL researchers developed a better understanding of the chemistry during catalysis of biomass pyrolysis products, which is leading the way to improved bio-oil properties.

Key Result

NREL researchers discovered that the zeolite catalyst deactivated quickly. This significant finding demonstrates that a greater separation of acid sites improves the efficiency of catalysts for producing hydrocarbon fuels and chemicals.

Potential Impact

The results are instrumental in designing reactors used for large-scale vapor phase upgrading. Johnson Matthey, a world leader in developing catalysts, will use the derived catalysis chemistry to develop the next generation of catalysts used for vapor phase upgrading.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

15013 Denver West Parkway
Golden, CO 80401
303-275-3000 | www.nrel.gov

NREL/FS-5100-64111 | June 2015

NREL prints on paper that contains recycled content.