NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NATIONAL
BIOENERGY CENTER

R&D WITH NREL'S **DAVISON CIRCULATING RISER (DCR) SYSTEM**

CORE CAPABILITIES

The DCR is a lab-scale recirculating riser reactor system coupled with an upstream custom pyrolyzer that evaluates the conversion of biomass- and waste-derived vapors and liquids into fuels and chemicals.

NREL researchers evaluate catalytic fast pyrolysis and refinery co-processing with petroleum feedstocks using fluid catalytic cracking (FCC)-type catalytic materials for a range of renewable and waste feedstocks. Clean pyrolysis vapors are achieved via hot gas filtration, and hot vapor analysis is available at multiple sampling points in the system.

Generated data includes:

- Mass and carbon balances
- Performance comparisons across feedstocks and catalysts
- Biogenic carbon content determination for petroleum and biomass feeds
- Catalyst regeneration efficiency.

Top Photo: NREL researchers monitor the upstream pyrolyzer in the DCR. *Photo by Dennis Schroeder, NREL 49325*

PROCESS FLEXIBILITY

Custom modifications to the DCR system provide a feedstock-flexible (vapors, liquids, and co-feeds) unit with enhanced product collection, carbon closure, vapor recycling, and catalyst retention.

HOT GAS FILTRATION

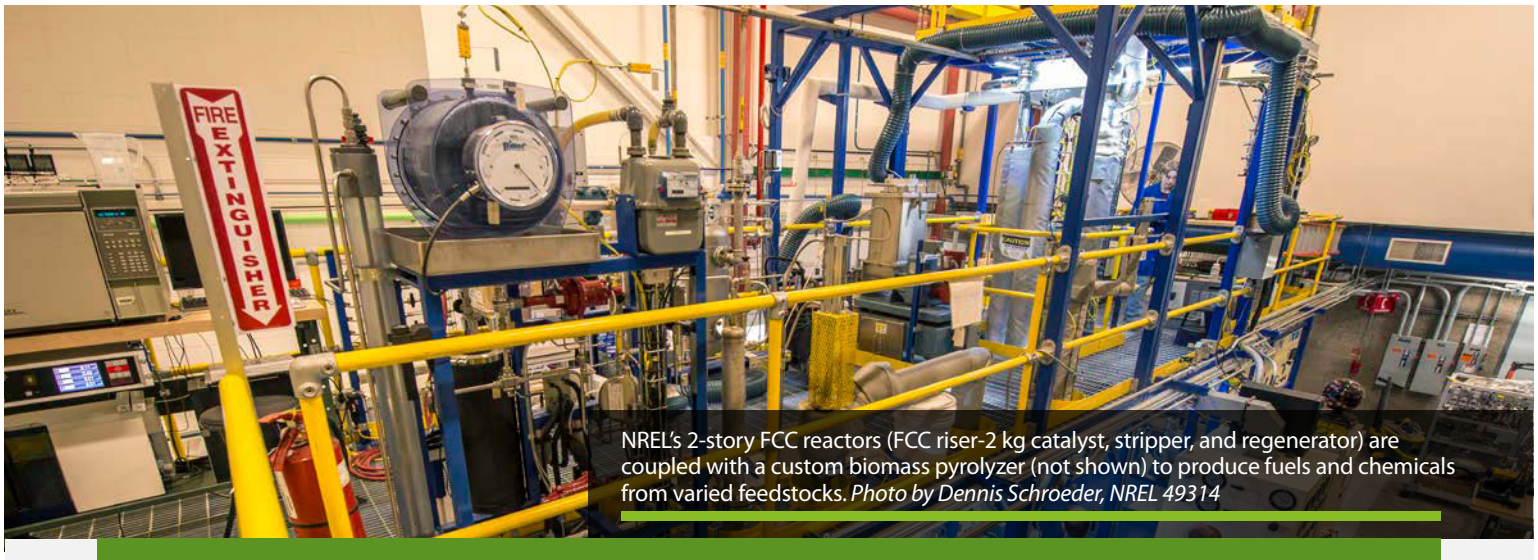
Hot gas filtration is used to remove reactive alkali and char particles from fast pyrolysis vapors to improve catalyst lifetime in downstream operations. Online hot gas analysis is provided by molecular beam mass spectrometry and gas chromatography.

CATALYST EVALUATION

Zeolites and metal-modified zeolites have been evaluated for hydrocarbon production. Continuous 8-hour runs generate approximately 400 milliliters of liquid product from pure biomass pyrolysis vapors at an oxygen content of 12 wt%–17 wt% and up to 8 liters of gasoline blendstocks from co-processing with vacuum gas oil (VGO). Coke on the catalyst is removed and quantified by *in situ* regeneration.

VAPOR AND LIQUID CONVERSION TO FUELS AND CHEMICALS

Product streams from the DCR are converted to fuels and chemicals: CFP oil is hydrotreated to gasoline and diesel blendstocks; co-processing CFP oil with VGO produces gasoline blendstocks; and chemical precursors like phenols are extracted from aqueous product streams.



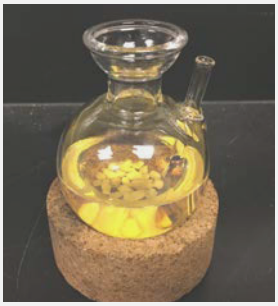
NREL's 2-story FCC reactors (FCC riser-2 kg catalyst, stripper, and regenerator) are coupled with a custom biomass pyrolyzer (not shown) to produce fuels and chemicals from varied feedstocks. *Photo by Dennis Schroeder, NREL 49314*

RECENT SUCCESSES

NREL's latest accomplishments include: (1) two liters of *ex situ*-upgraded CFP oil from pine pyrolysis vapors were hydrotreated to gasoline and diesel blendstocks and (2) tracking added guaiacol during VGO conversion to gasoline showed that guaiacol forms phenolics.

Recently, NREL produced 2 liters of CFP oil from southern pine pyrolysis vapors upgraded with a commercial zeolite-based FCC catalyst. The oil was hydrotreated at Pacific Northwest National Laboratory to produce gasoline and diesel blendstocks. In addition, NREL's assessment of the impact of representative biomass pyrolysis compounds on co-processing with petroleum feedstocks showed that adding guaiacol during VGO conversion to gasoline formed phenolics while enhancing aromatics in the finished fuel.

DCR CFP Oil
JM ZSM-5



Hydrotreated CFP Oil

Gasoline and Diesel Blendstocks

Highlighted Publication

M. Jarvis, et al. "Catalytic Upgrading of Biomass Pyrolysis Oxygenates with Vacuum Gas Oil (VGO) using a Davison Circulating Riser Reactor." *Energy & Fuels*. DOI: 10.1021/acs.energyfuels.7b02337

Find Out More

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