



## Thermal and Catalytic Processing Capabilities at NREL

Advanced Development and Optimization (ADO) Workshop

December 12-13, 2017

# MULTI-SCALE THERMAL DECONSTRUCTION

- Ability to perform pyrolysis and gasification
- Feedstock flexible
- Entrained Flow and Fluid Bed Reactor technologies available
- Grams to tens of kilograms biomass per hour throughput
- Solid, liquid, and gas feeds possible

## Understanding deconstruction across scales



Fundamental studies of thermochemical reactions and kinetics

Rapid evaluation of emerging process technologies



Evaluation of long-term process and equipment performance

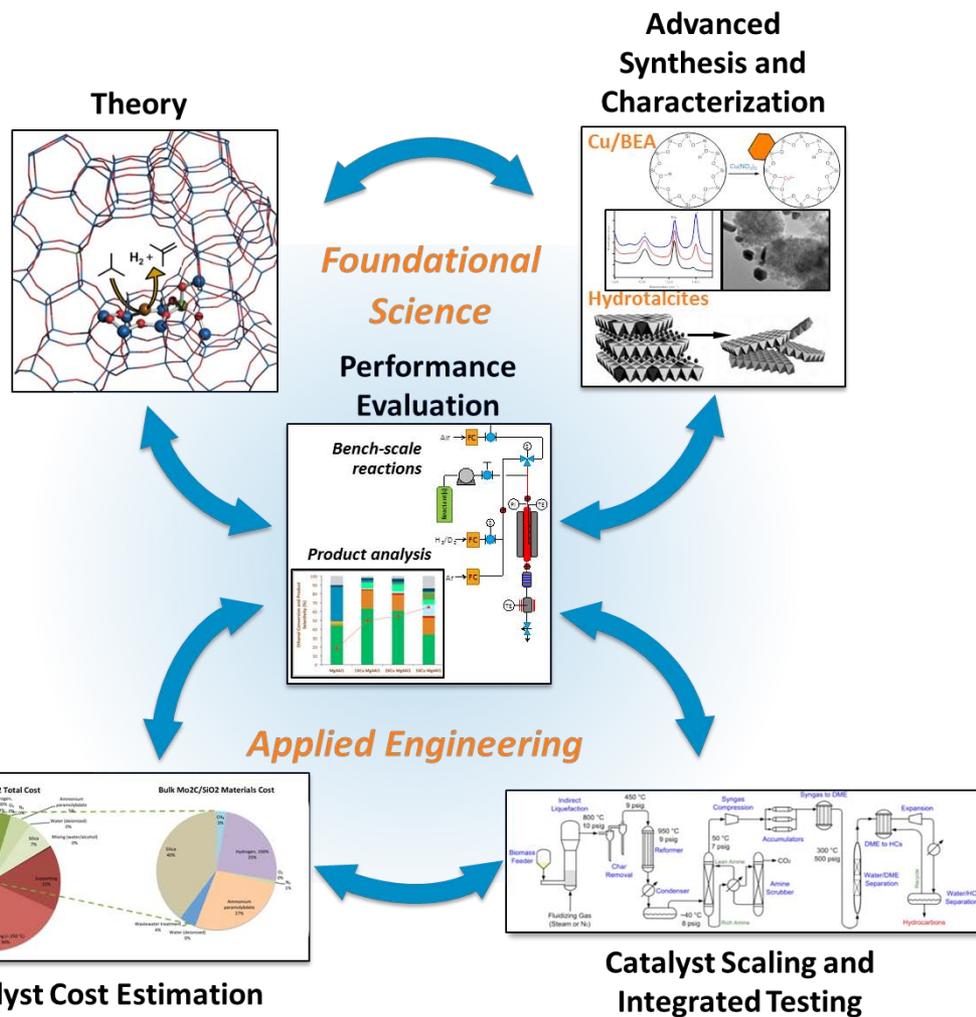


# MULTI-SCALE CATALYTIC UPGRADING

## Linking foundational science and applied engineering to develop and evaluate catalysts for synthesis of fuels and chemicals

### Integrated Testing

- Feed stream flexibility
  - Stand alone or coupled operation with upstream deconstruction systems
  - Accept biological streams for hybrid conversion approaches
- Riser/CFB, fluid bed, and packed bed reactor technologies available (1g – 100kg<sub>cat</sub> scale)
- CFD models of reactors provide fundamental insight into operations
- Evaluation of co-processing strategies



\*In collaboration with ChemCatBio

# EXTENSIVE IN-HOUSE ANALYTICS

## Unparalleled Expertise



Enabling process evaluation through comprehensive stream characterization

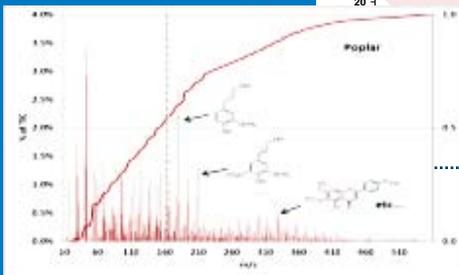
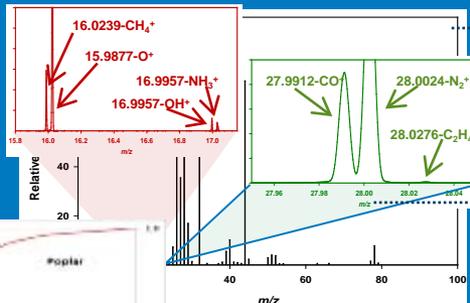
### **First ASTM Method for pyrolysis oil analysis (D7544)**

The first ASTM method for measuring carbonyl content of pyrolysis oil was developed in part by NREL

### **NREL develops Laboratory Analytical Procedures**

Over a dozen LAPs for biomass, liquid/gas intermediates, and end product compositions have been developed and distributed by NREL researchers

## Specialized Analytical Systems

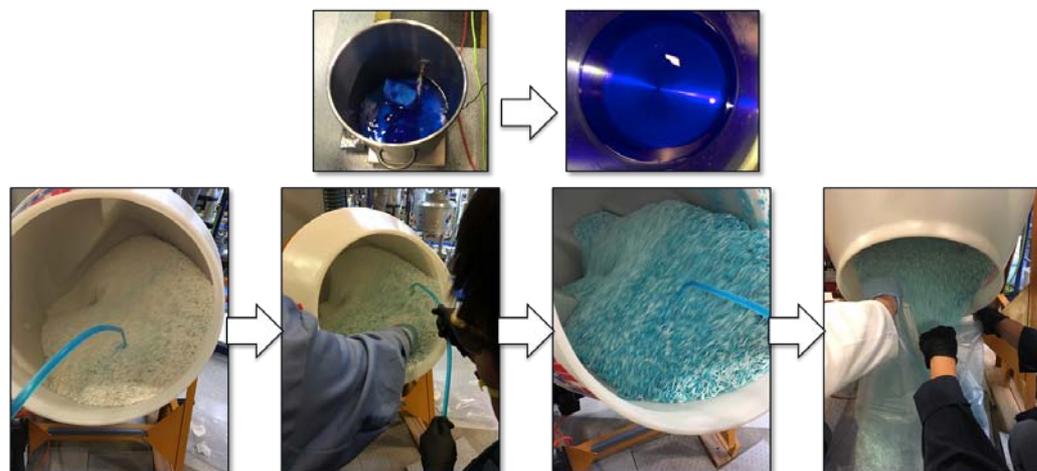


- **Molecular Beam Mass Spectrometry**  
NREL is home to 4 molecular beam mass spectrometers (deployable)
- **High Temperature Gas Chromatography**  
Provides nitrogen and sulfur heteroatom speciation on high temperature process streams
- **High-Resolution Pyroprobe MS**  
Provides rapid evaluation of product speciation in real-time

# CATALYST SCALE-UP AND CHARACTERIZATION

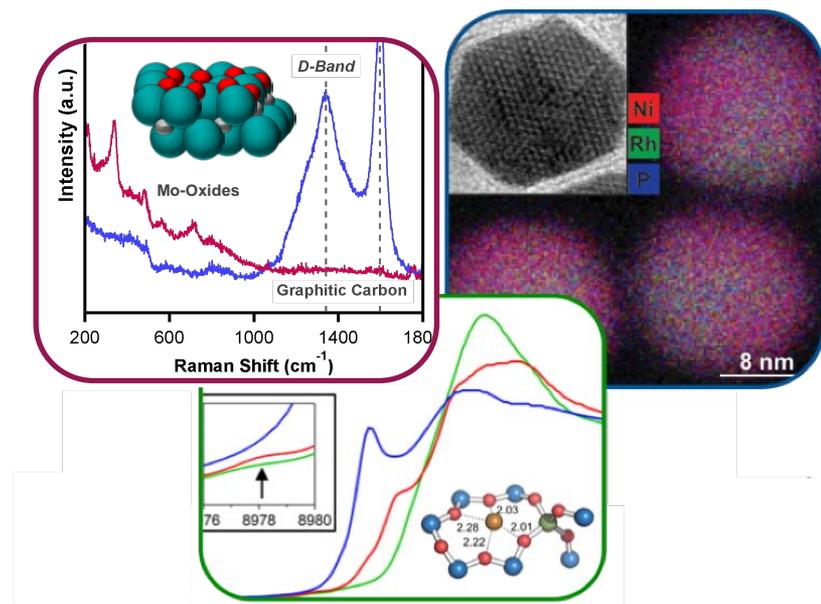
Overcoming process scale-up challenges by coupling scaled catalyst production with comprehensive catalyst characterization and multi-scale evaluation

*Demonstrated capability and expertise in catalyst production at intermediate scales*



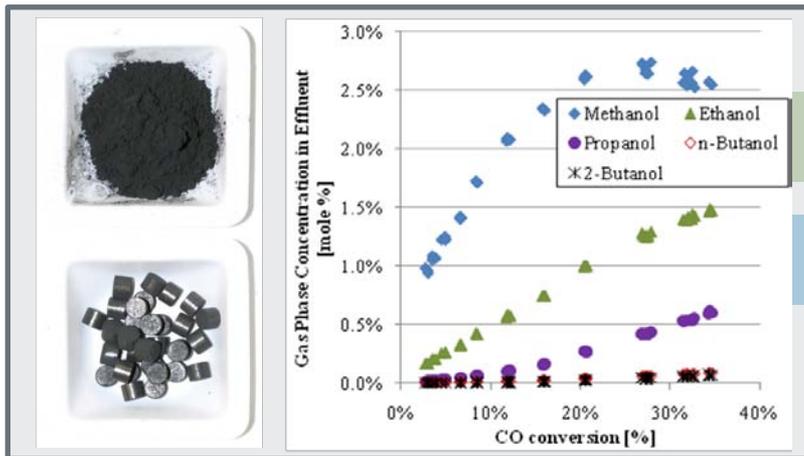
100kg of metal-modified zeolite for engineering-scale evaluation

*Demonstrated capability and expertise in advanced in-situ/in-operando catalyst characterization*



\*In collaboration with ChemCatBio (ANL/ORNL)

# CLIENT COLLABORATION



Syngas to Ethanol

The Dow Chemical Company



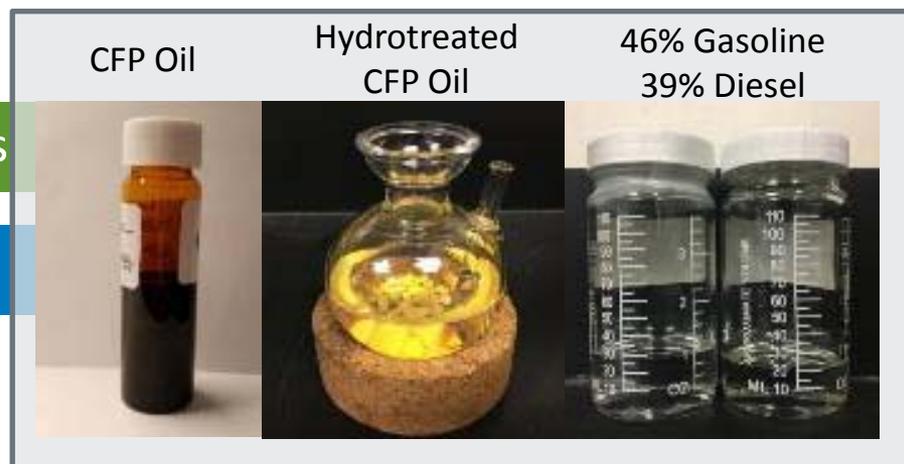
Improved a mixed alcohol synthesis catalyst and rigorously modeled process economics in collaboration with The Dow Chemical Company

Catalytic Fast Pyrolysis to Fuels

Johnson Matthey



Johnson Matthey



Developed an FCC catalyst for upgrading biomass pyrolysis vapors to hydrocarbon fuels in conjunction with Johnson Matthey

# OUR TEAM

## Leverage our expertise to solve your company's challenges

- Dedicated operators and engineers for our integrated engineering-scale systems
- Diverse team spanning from inorganic chemistry and chemical engineering to computational science and process modeling
- Demonstrated success working with industry partners
- Access to capabilities across the national lab system through consortia



Co-Optimization of  
Fuels & Engines



**For more information, please contact:**

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