

Fuel Synthesis Catalysis Laboratory

Catalytic testing for high pressure gas-to-fuels technologies

NREL's Fuel Synthesis Catalysis Laboratory provides a wide range of capabilities in high-pressure heterogeneous catalyst testing. Current research areas of emphasis are hydrocarbon synthesis from biomass-derived syngas and pyrolysis vapors. Many other catalyst systems can be studied by making minor system modifications.

The lab utilizes six reactors for gas-to-liquids and liquid-to-liquids synthesis:

- Three bench-scale tubular (integral) reactors
- Two bench-scale stirred autoclave (differential) reactors
- One temperature-programmed screening system.

NREL's bench-scale high pressure reactors provide:

- 24/7 operation
- Catalyst performance data over a range of temperatures and pressures
- Robust analysis of reaction products.

Applications include:

- Catalyst screening and ranking
- Lifetime testing
- Kinetic modeling support
- Simulated recycle.



This bench-scale fuel synthesis reactor can be used to test various catalysts over a wide range of conditions using bottled or biomass-derived syngas. *Photo by Jesse Hensley, NREL 19329*

Fuel Synthesis Catalyst Testing Equipment Specifications

Systems	10 mL isothermal tubular reactor 40 mL isothermal tubular reactor 1 L stirred autoclave reactors (batch, Berty, slurry)
On-line product analysis	Gas chromatography Hydrocarbons (lower detection limit [ldl] 10 ppm) Oxygenates (non-acid FID/TCD/MS/SCD) (ldl 10 ppm) Permanent gases (ldl 50 ppm) Mass spectral analysis for identification
Operating conditions	Sample size: 500 mg – 4 g (0.2 – 2 mL sans dilution) Gas flow: 5 – 200 g/h Pressure: atmospheric to 2,000 psi Temperature: 100 C° - 500 C° Gases: CO/H ₂ /Ar/He/N ₂ /CO ₂ /CH ₄ /H ₂ S custom blended on-site Liquids: Any of reasonable viscosity
Catalysts (solid)	Metals Carbides Aluminosilicates Sulfides Size: >50 μ particles
Mass/atomic balances	± 3% typical

Applications

Catalyst screening and performance evaluation

- Efficient screening of catalyst performance at steady state
- Ranking of multiple catalyst samples.

Medium-range catalyst lifetime testing

- Steady state operation
- Continuous catalyst testing for 1,000 to 2,000 hours or longer.

Kinetic model development

- Reactors operated with negligible temperature and concentration gradients provide high quality data for kinetic modeling
- State of the art analytical system provides rigorous and accurate product analysis from low to medium-high conversion.

Use of biomass-derived syngas made in NREL's thermochemical process development unit (TCPDU)

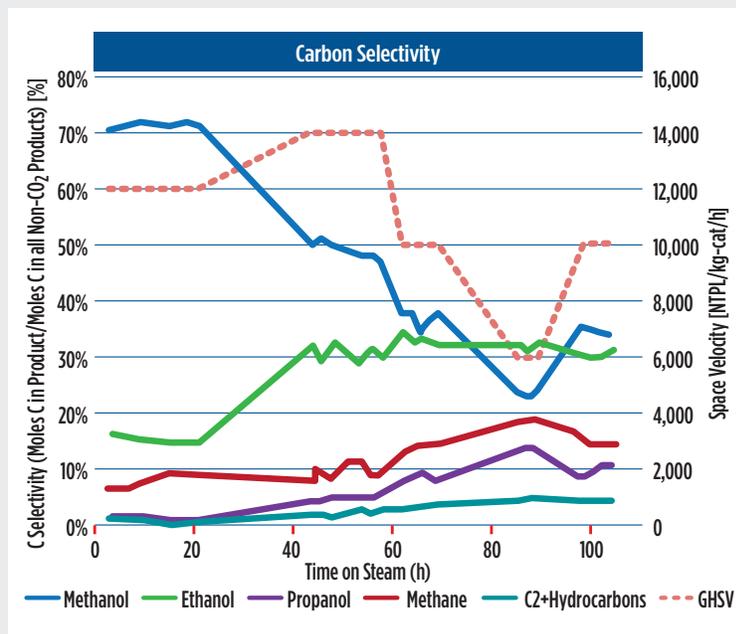
- Compare catalyst performance in bottled vs. "real" syngas
- Compare bench-scale and mini-pilot-scale performance using fuel synthesis catalysis and thermochemical biorefinery pilot plant labs.

Simulated recycle

- Recycle streams can be simulated by blending gas and vapor mixtures to match probable recycle compositions.

Other capabilities

- NMR and TPO of deactivated catalysts to determine rates of coke formation
- Temperature programmed reaction/desorption/decomposition/oxidation/reduction including pulse TPX.



Sample data from a mixed alcohol catalyst operated at 325°C and 1,500 psig.
Figure by NREL

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