

FLOW REACTOR DESIGNS

SOLUTIONS FOR MAJOR INDUSTRIAL PROCESSES

micromeritics.com/FR



FISCHER-TROPSCH

CONTINUOUS FLOW REACTOR CONFIGURATION

Standard Configuration

- **L/L/G Separator** to divide the organic and aqueous phases for continuous product analysis.
- **Wax Trap** at reactor outlet to prevent plugging.
- **Heated Lines & Chamber** for stable and reproducible reaction conditions.



L/L/G Separator



Wax Trap



Heated Lines & Chamber



Autosampler



Automated Bypass Valve



Analyzer Software Integration



Flow Reactor System

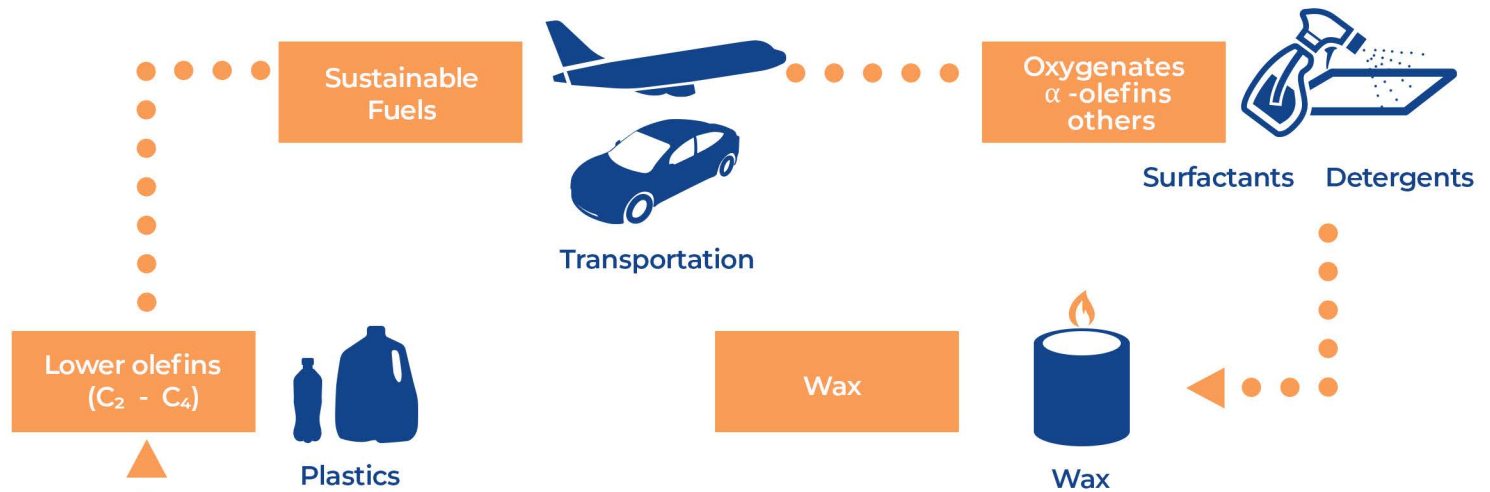
Recommended Options

- **Integrated Liquid & Gas Outlet Measurements** to determine mass balance and reaction yield.
- **Autosampler** to study the liquid product at user-defined intervals.
- **Automated Bypass Valve** allows complete product stream to be analyzed.
- **Analyzer Software Integration** to optimize the kinetics, selectivity, and yield.
- **Independent dual reactor** model (FR 200) available to double throughput.

Integrated Liquid / Gas Outlet Measurements

FISCHER-TROPSCH SYNTHESIS

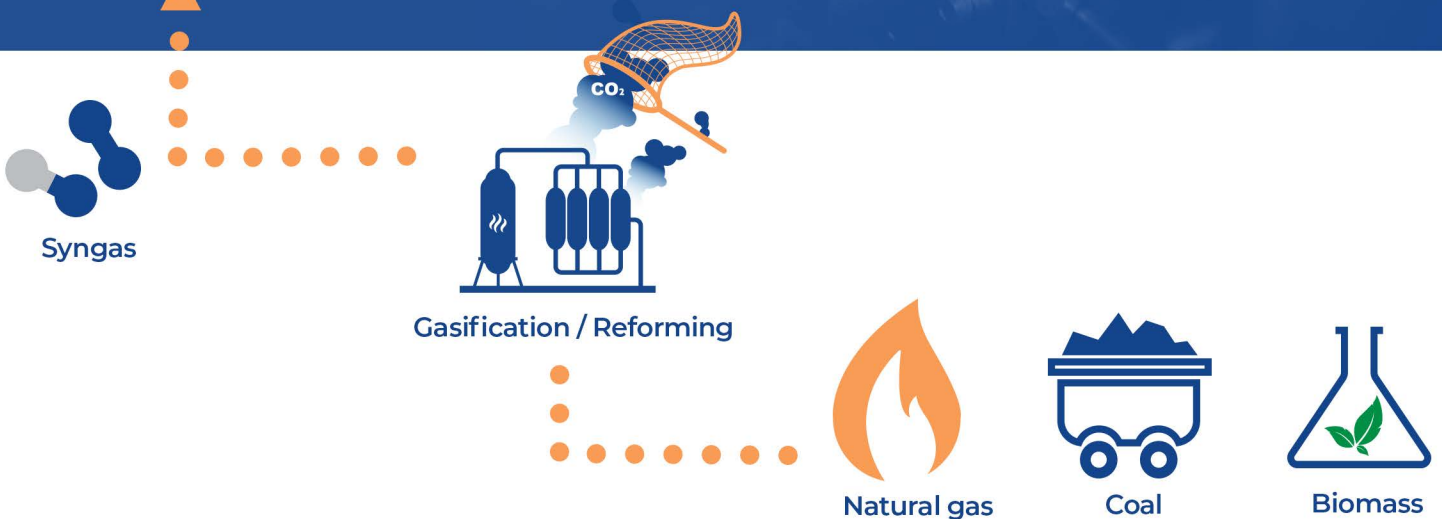
Liquid Hydrocarbons & Wax



Liquid fuels and other chemical products can be produced from syngas via the well-known and catalytic chemical process called **Fischer-Tropsch** (FT) synthesis.



FISCHER-TROPSCH SYNTHESIS

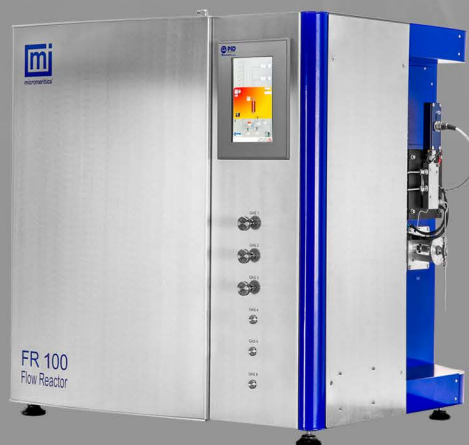


AMMONIA SYNTHESIS/DECOMPOSITION

FLEXIBLE REACTOR PLATFORM

Standard Configuration

- **Gas Inlets** for N₂, H₂, and inert gas standard.
- **High-Resolution Pressure Control** with patented valve up to 100 (+/- 0.1) bar.
- **Heated Lines & Chamber** to avoid condensation of ammonia.
- **Analyzer Software Integration** to optimize the kinetics, selectivity, and yield.



Flow Reactor (FR-100)

Recommended Options

- **Safety Gas Sensors** to detect H₂ and NH₃ leaks integrated with safety system.
- **High Pressure Dosing System** to feed liquefied NH₃ gas to study its decomposition to produce H₂.
- **Materials of Construction** are available to match demanding operating conditions.



Gas Inlets



High-Resolution Pressure Control



High Pressure Dosing System



Heated Lines & Chamber



Analyzer Software Integration



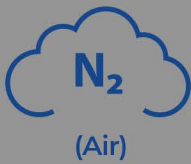
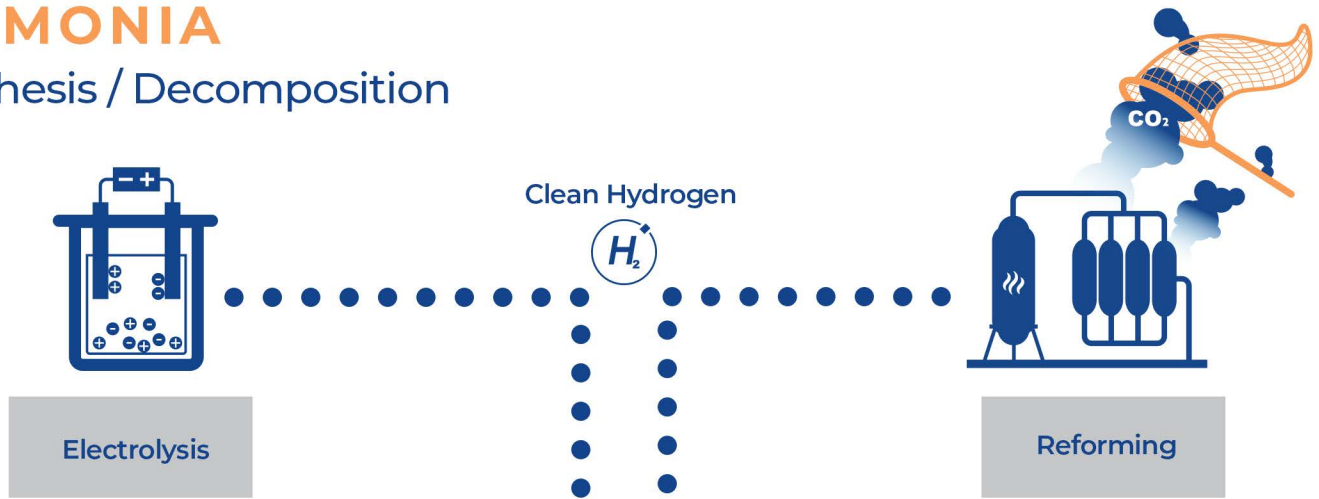
Safety Gas Sensors



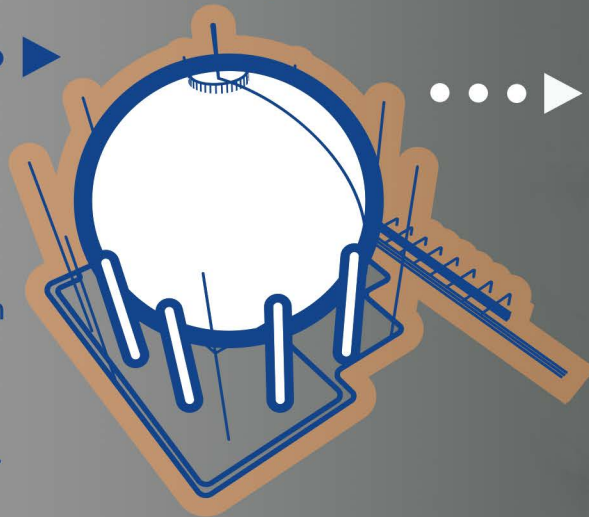
Materials of Construction for the Reactor

AMMONIA

Synthesis / Decomposition



The **Haber-Bosch** process, is an artificial nitrogen fixation process and is the main industrial procedure for the production of ammonia today.



AMMONIA SYNTHESIS

Clean Ammonia



NH₃ storage



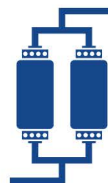
Fertilizer



Marine Fuel



Chemical Precursor



Ammonia Decomposition



Hydrogen



Fuel Cells and other applications

METHANOL SYNTHESIS (AND HIGHER ALCOHOLS)

ADAPTABLE FLOW REACTOR DESIGNS

Standard Configuration

- **Gas Inlets** for reactants (CO, CO₂, & H₂) and inert gas standard.
- **Patented L/G Separator** with low dead volume for accurate catalyst activity and reaction kinetics studies.
- **High-Resolution Pressure Control** up to 100 (+/- 0.1) bar.



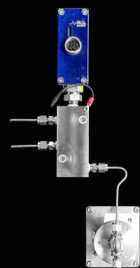
Flow Reactor (FR-100) Interior

Recommended Options

- **Wax Trap** mandatory for higher alcohol synthesis or when high MW compounds are expected.
- **Safety Gas Sensors** to detect H₂ leaks integrated with safety system.
- **Coriolis Mass Flow Controller** for CO₂ feed between 30-50 bar or **High-Pressure** option for CO₂ dosing up to 200 bar.
- **Materials of Construction** are available to match demanding operating conditions.
- **Integrated Liquid Outlet Measurements** to determine mass balance and yield.



Gas Inlets



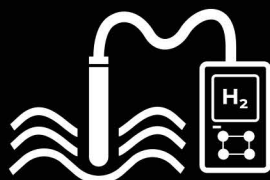
L/G Separator



High-Resolution Pressure Control



Wax Trap



Safety Gas Sensors



Coriolis Mass Flow Controller



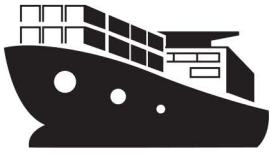
Materials of Construction for the Reactor



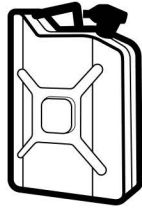
Integrated Liquid Outlet Measurements

METHANOL SYNTHESIS

And Higher Alcohols



Marine Fuel



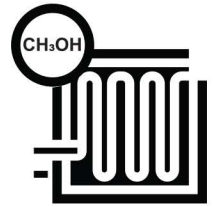
BioDiesel



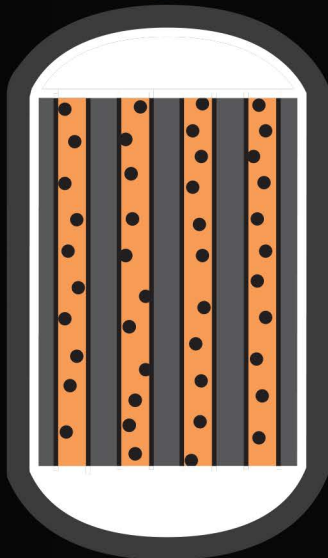
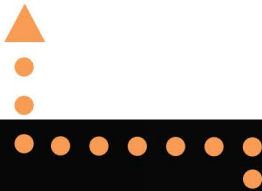
Plastics



Pharmaceutical
Products



Fuel Cells



One route to produce methanol is characterized by the addition of carbon dioxide to hydrogen.



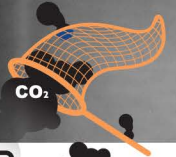
METHANOL SYNTHESIS



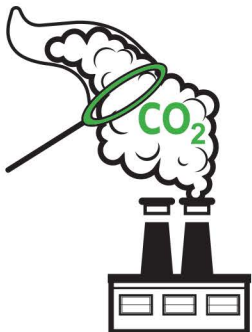
Carbon Dioxide



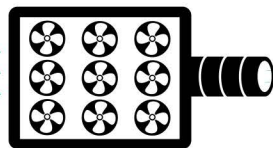
Clean Hydrogen



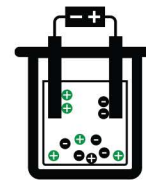
CO₂



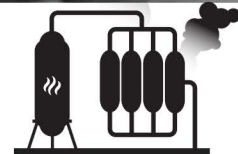
Industrial
Carbon Capture



Direct
Air Capture



Green
Electrolysis



Steam Reforming



Biomass

STEAM / DRY REFORMING

CONTINUOUS FLOW REACTOR CAPABILITIES

Standard Configuration

- **Gas Inlets** for reactants (CH₄ & CO) and inert gas standard.
- **Patented L/G Separator** with low dead volume for accurate catalyst activity and reaction kinetics studies.
- **Liquid HPLC Pump** with integrated mass flow meter for precise, stable feed control of water plus a **Liquid Evaporator** to generate steam.
- **Materials of Construction** are available to match demanding operating conditions.



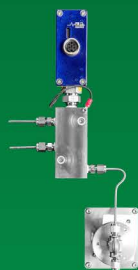
Flow Reactor (FR-200) Interior

Recommended Options

- **Safety Gas Sensors** to detect H₂ and CO leaks integrated with safety system.
- **Additional Gas Inlets** for CO₂ for dry reforming, air/O₂ for catalyst regeneration, or H₂.
- **Integrated Gas Outlet Measurements** to determine mass balance and reaction yield.



Integrated Liquid / Gas Outlet Measurements



L/G Separator



Liquid HPLC Pump



Liquid Evaporator



Materials of Construction for the Reactor



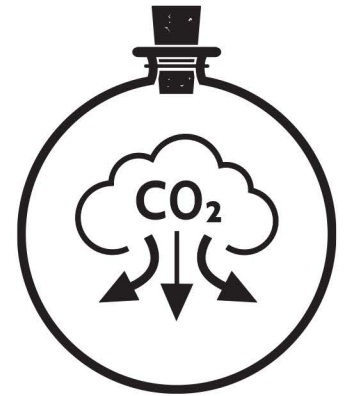
Safety Gas Sensors

REFORMING

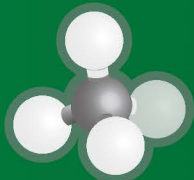
Steam & Dry



Natural Gas



CO₂ Capture



Methane

CO₂

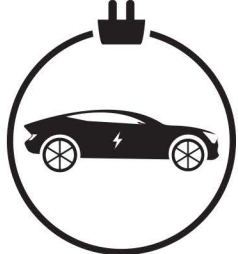
Steam methane reforming (SMR) is a process in which natural gas is heated with steam to produce a mixture of carbon monoxide and hydrogen used in organic synthesis.



H₂ PRODUCTION



Clean Hydrogen



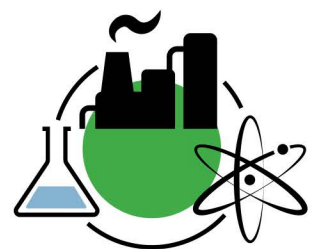
Fuel Cell
Electric Vehicle



Sustainable
Aviation Fuels



Ammonia
/ Fertilizer



Chemical
Processes

SABATIER PROCESS

FLOW REACTOR MODULAR CAPABILITIES

Standard Configuration

- **Patented L/G Separator** for the efficient separation and recovery of liquid streams (H_2O).
- **Gas Inlets** for reactants (CO_2 & H_2) and inert gas standard.
- **High-Resolution Pressure Control** up to 100 (+/- 0.1) bar.



Flow Reactor System

Recommended Options

- **Safety Gas Sensors** inside the thermostatic chamber to detect H_2 leaks are integrated with safety system.
- **Materials of Construction** are available such as, a Quartz Reactor for ambient pressure and high temperature studies.



L/G Separator



Gas Inlets



High-Resolution Pressure Control



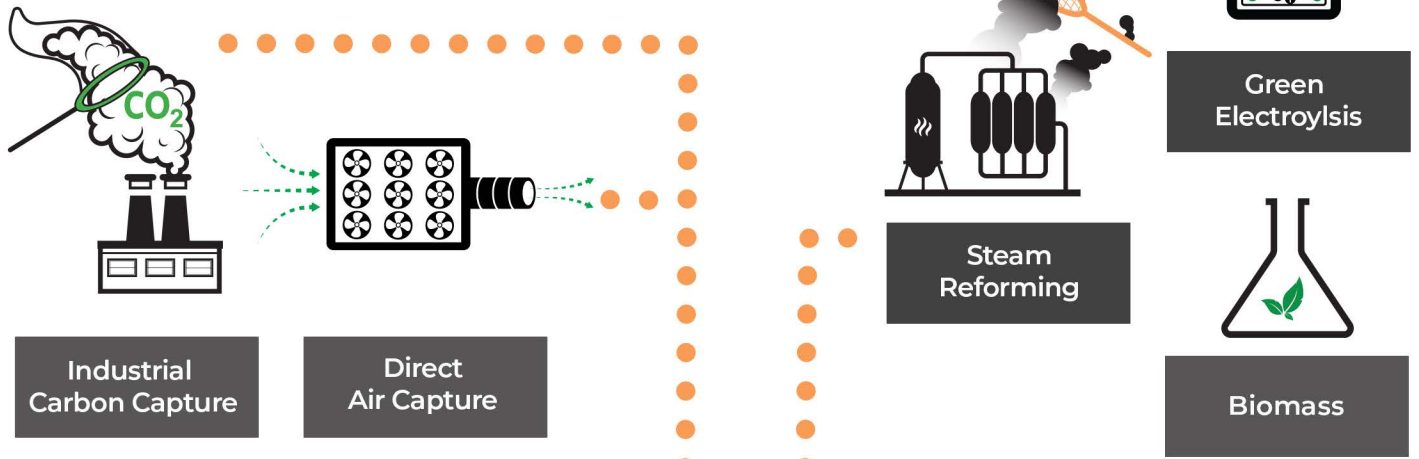
Safety Gas Sensors



Materials of Construction for the Reactor

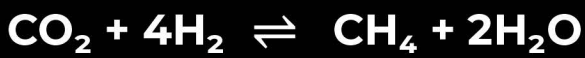
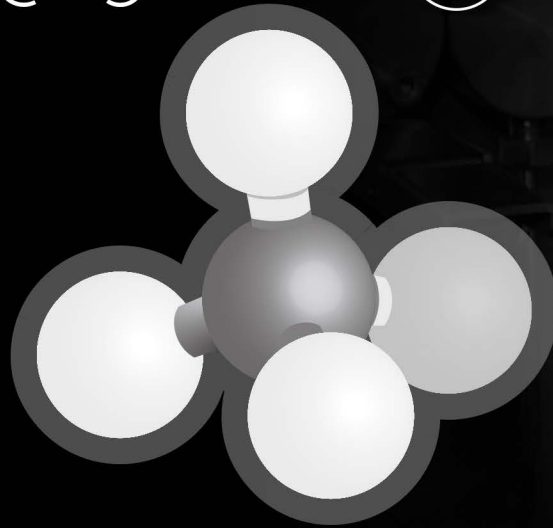
SABATIER PROCESS

Methane Production



The **Sabatier Process** produces methane and water from a reaction of hydrogen with carbon dioxide at elevated temperatures.

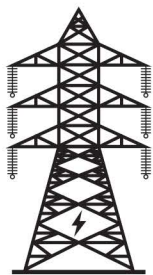
Carbon Dioxide   Clean Hydrogen



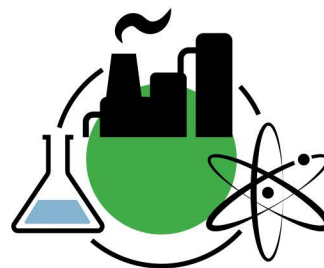
Sabatier Process



Heating



Electricity



Other Industrial Uses



Sustainable Vehicle Fuel

HYDROGENATION

ADAPTABLE FLOW REACTOR PLATFORM

Standard Configuration

- **Patented L/G Separator** with low dead volume for accurate catalyst activity and reaction kinetics studies.
- **Liquid HPLC Pump** with integrated mass flow meter for precise, stable feed control & temperature control up to 80°C for heavy hydrocarbons.



L/G Separator



Liquid HPLC Pump



Flow Reactor (FR-200)

Recommended Options

- **Integrated Liquid & Gas Outlet Measurements** to determine mass balance and reaction yield.
- **Autosampler** to study the liquid product at user-defined intervals.
- **Automated Bypass Valve** to sample all vapor phase products to understand kinetics.
- **Safety Gas Sensors** to detect H₂ leaks integrated with safety system.
- **Liquid Evaporator** (50-450°C) for researchers who need to vaporize their liquid feed stocks.



Integrated Liquid / Gas Outlet Measurements



Autosampler



Automated Bypass Valve



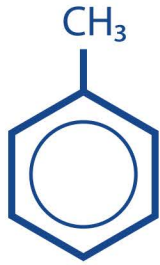
Safety Gas Sensors



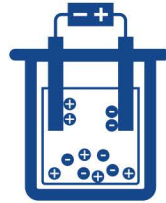
Liquid Evaporator

HYDROGENATION

& Dehydrogenation



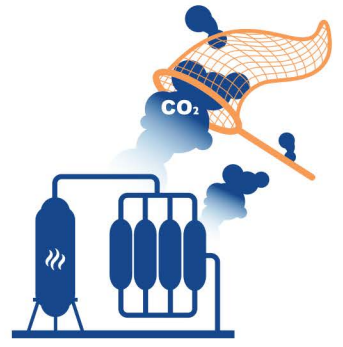
Toluene
Feed-Stock



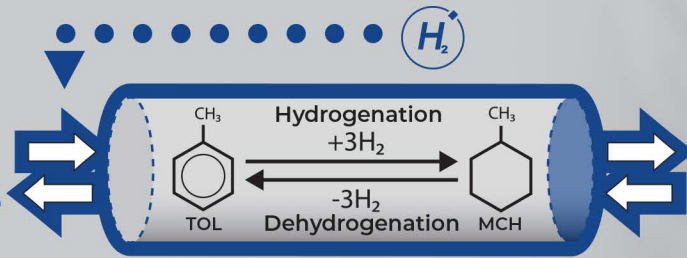
Electrolysis



Biomass

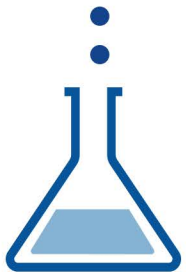


Steam
Reforming

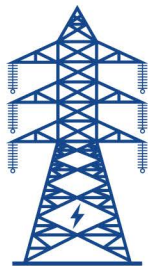


Liquid Organic
Hydrogen Carrier

Hydrogenation is a chemical reaction between hydrogen and another compound, usually in the presence of a catalyst.



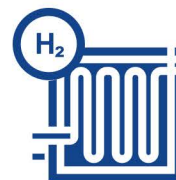
Chemical Industry



Power Generation



Heating



Fuel Cells

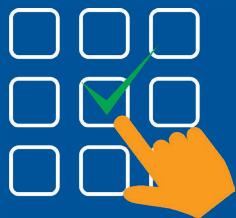
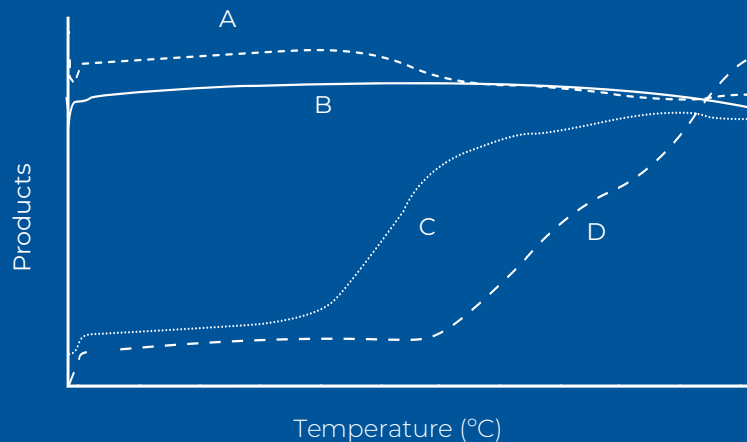


Sustainable
Aviation Fuel

FLEXIBLE REACTOR PLATFORM

ADAPTABLE TO A WIDE-RANGE OF CHEMICAL REACTIONS

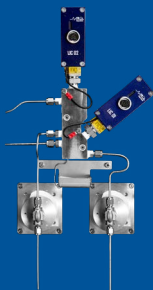
The **FR-series** flow reactor modular capabilities support a wide-range of catalytic chemical reactions. Input streams, reactant flow, operating conditions, and output analysis can be configured to meet your specific needs.



Dozens of options



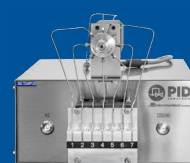
High Resolution Pressure Valve



L/L/G Separator



High Pressure Dosing System



Autosampler



Materials of Construction

In-Situ Catalyst Characterization System (ICCS)

Advanced Characterization Unit for the Flow Reactor

The Micromeritics ICCS offers advanced catalyst characterization for the Flow Reactor to understand the effects of reaction conditions on critical parameters.

- Characterization without the need to remove the catalyst from the reactor.
- Use of TPR, TPD, TPO, as well as Pulse Chemisorption.
- Analysis can be performed both before and after the reaction.
- High pressure capabilities.

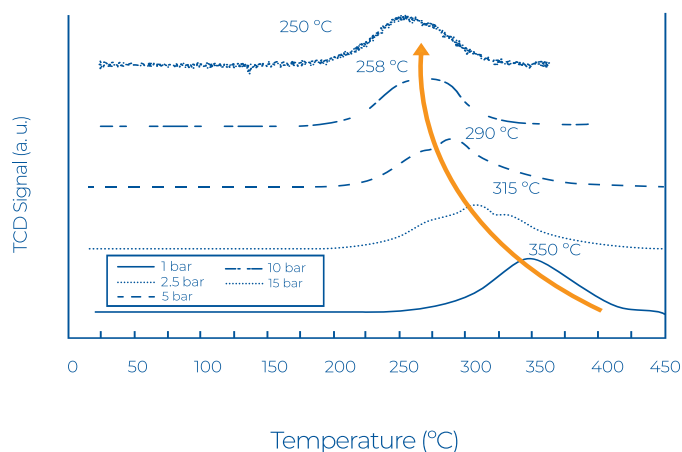
Benefits of In-Situ catalyst Characterization

- Monitor changes in active sites, oxidative states, metal dispersion, and desorption behavior.
- Determine deactivation mechanism to maximize a catalysts' lifetime.
- Understand changes in performance over extended periods.



ICCS

PRESSURE IMPACT ON REDUCTION TEMPERATURE



This figure shows the shift on the reduction temperature of a CuO catalyst as function of increasing pressure.

SCAN QR CODE FOR
MORE INFORMATION



CONTACT US TODAY!

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