FLOW REACTOR DESIGNS

SOLUTIONS FOR MAJOR INDUSTRIAL PROCESSES

micromeritics.com/FR

micromeritics®

FISCHER-TROPSCH

CONTINUOUS FLOW REACTOR CONFIGURATION

Flow Reactor System

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

Integrated Liquid / Gas Outlet Measurements

Autosampler

Automated Bypass Valve

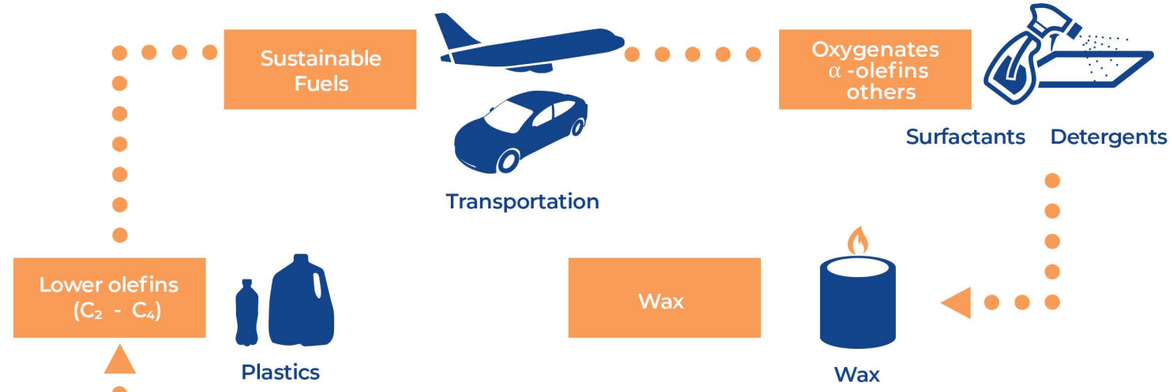
Analyzer Software Integration

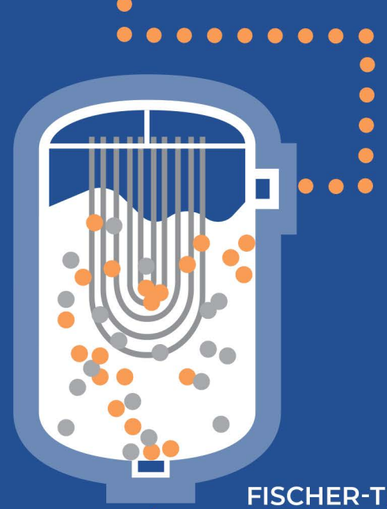
Recommended Options

- **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.

FISCHER-TROPSCH SYNTHESIS

Liquid Hydrocarbons & Wax

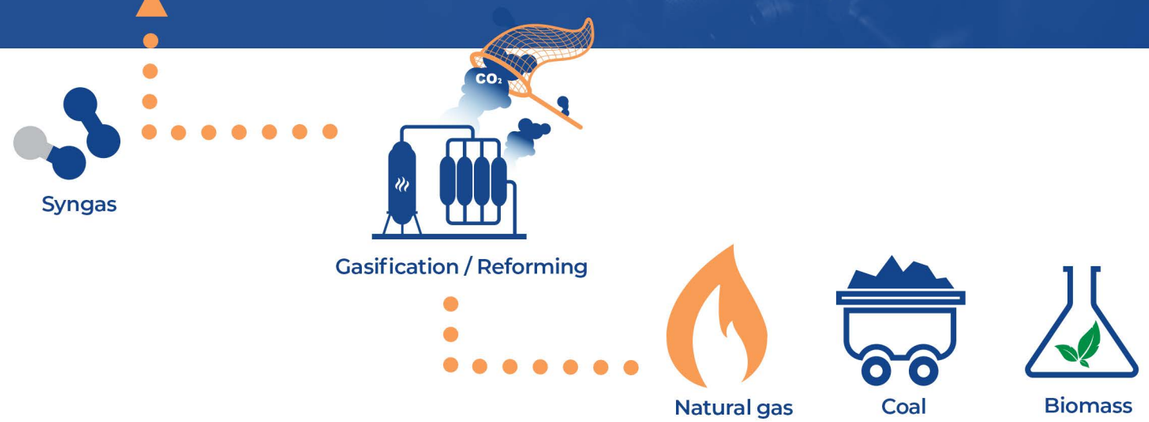




Liquid fuels and other chemical products can be produced from syngas via the well-known and catalytic chemical process called **Fischer-Tropsch** (FT) synthesis.

$$2n\ H_2 + CO \longrightarrow -(CH_2-)_n + H_2O$$

FISCHER-TROPSCH SYNTHESIS



AMMONIA
SYNTHESIS/DECOMPOSITION

FLEXIBLE REACTOR PLATFORM

Standard Configuration

- **Gas Inlets** for N_2, H_2, 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 H_2 and NH_3 leaks integrated with safety system.
- **High Pressure Dosing System** to feed liquefied NH_3 gas to study its decomposition to produce H_2.
- **Materials of Construction** are available to match demanding operating conditions.

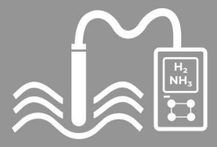
Gas Inlets

High-Resolution Pressure Control

High Pressure Dosing System

Heated Lines & Chamber

Analyzer Software Integration

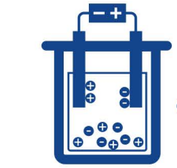


Safety Gas Sensors

Materials of Construction for the Reactor

AMMONIA

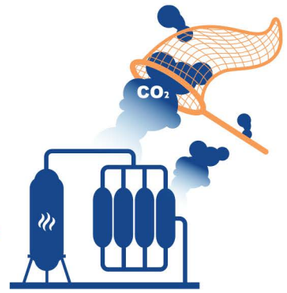
Synthesis / Decomposition



Electrolysis

Clean Hydrogen

H_2

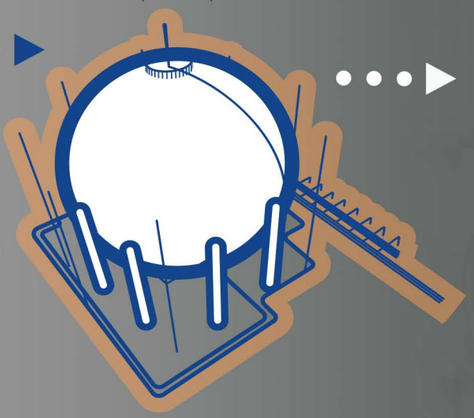


Reforming

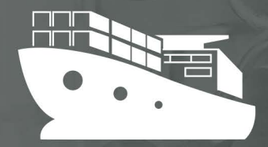
N_2

(Air)

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

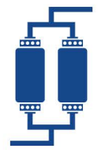
NH_3 storage

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Fertilizer

Marine Fuel

Chemical Precursor



Ammonia Decomposition

Hydrogen

Fuel Cells and other applications

micromeritics

METHANOL SYNTHESIS (AND HIGHER ALCOHOLS)

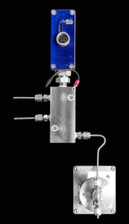
ADAPTABLE FLOW REACTOR DESIGNS

Standard Configuration

- **Gas Inlets** for reactants (CO, CO_2, & H_2) 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

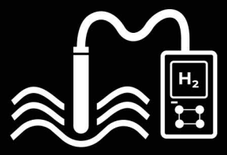
Gas Inlets



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

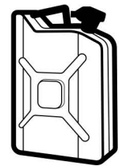
Recommended Options

- **Wax Trap** mandatory for higher alcohol synthesis or when high MW compounds are expected.
- **Safety Gas Sensors** to detect H_2 leaks integrated with safety system.
- **Coriolis Mass Flow Controller** for CO_2 feed between 30-50 bar or **High-Pressure** option for CO_2 dosing up to 200 bar.
- **Materials of Construction** are available to match demading operating conditions.
- **Integrated Liquid Outlet Measurements** to determine mass balance and yield.

METHANOL SYNTHESIS

And Higher Alcohols

Marine Fuel

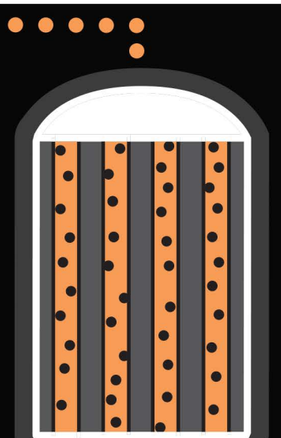


BioDiesel

Plastics

Pharmaceutical Products

Fuel Cells



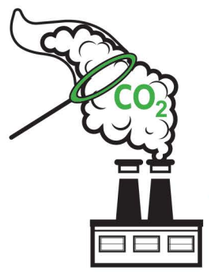
One route to produce methanol is characterized by the addition of carbon dioxide to hydrogen.

$$CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O$$

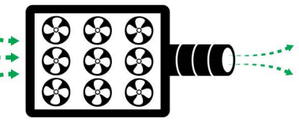
METHANOL SYNTHESIS

CO_2 Carbon Dioxide

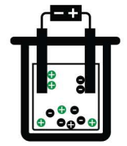
H_2 Clean Hydrogen



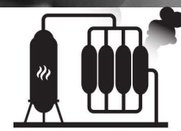
Industrial Carbon Capture



Direct Air Capture



Green Electrolysis



Steam Reforming

Biomass

STEAM / DRY REFORMING

CONTINUOUS FLOW REACTOR CAPABILITIES

Standard Configuration

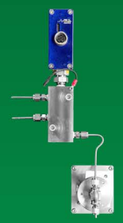
- **Gas Inlets** for reactants (CH_4 & CO) and inert gas standard.
- **Patented L/G Separator** with low dead volume for accurate catalyst activity and reaction kinetics studies.
- **Liquid HPLC Pump** with integrated mass flow meter for precise, stable feed control of water plus a **Liquid Evaporator** 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 H_2 and CO leaks integrated with safety system.
- **Additional Gas Inlets** for CO_2 for dry reforming, air/O_2 for catalyst regeneration, or H_2.
- **Integrated Gas Outlet Measurements** to determine mass balance and reaction yield.

Integrated Liquid / Gas Outlet Measurements



L/G Separator

Liquid HPLC Pump

Liquid Evaporator

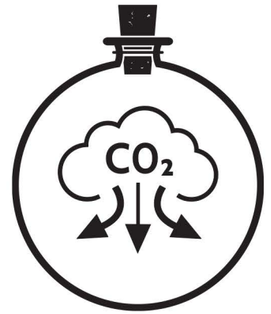
Materials of Construction for the Reactor

Safety Gas Sensors

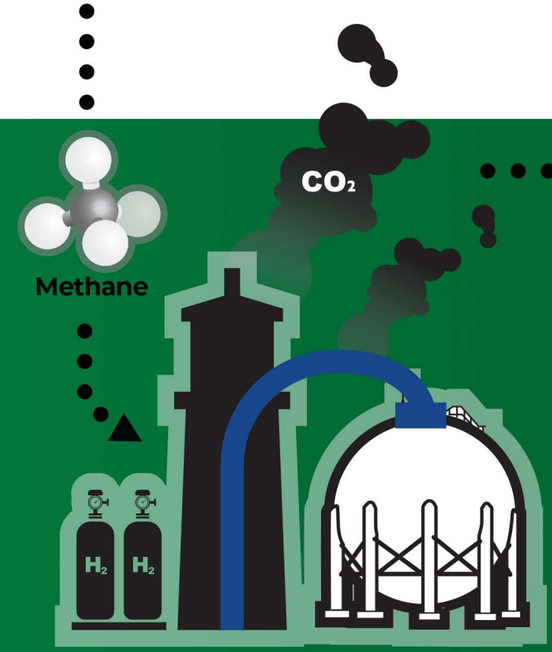
REFORMING

Steam & Dry

Natural Gas



CO_2 Capture



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.

$$CH_4 + H_2O \leftrightarrow CO + 3H_2$$

H_2 PRODUCTION

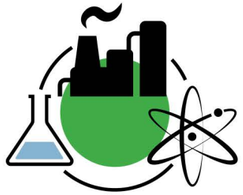
H_2

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

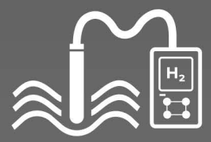
Recommended Options

- **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

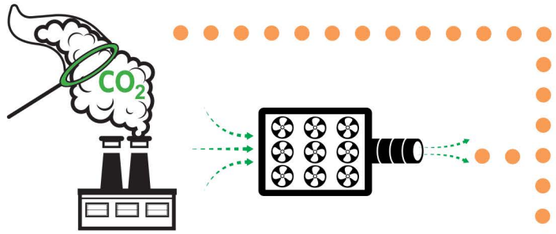


Safety Gas Sensors

Materials of Construction for the Reactor

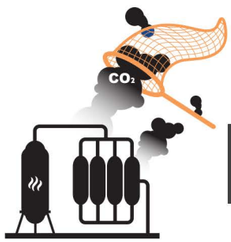
SABATIER PROCESS

Methane Production

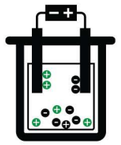


Industrial Carbon Capture

Direct Air Capture



Steam Reforming



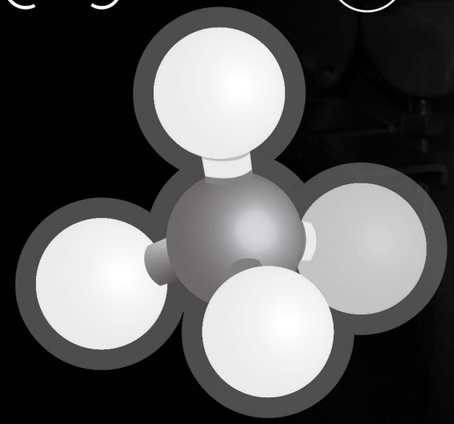
Green Electroylsis

Biomass

Carbon Dioxide CO_2

H_2 Clean Hydrogen

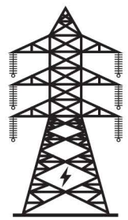
The **Sabatier Process** produces methane and water from a reaction of hydrogen with carbon dioxide at elevated temperatures.



$CO_2 + 4H_2 \rightleftharpoons CH_4 + 2H_2O$

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.

Flow Reactor (FR-200)

L/G Separator

Liquid HPLC Pump

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 H_2 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

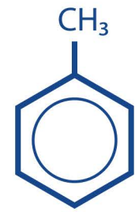
Automated Bypass Valve

Safety Gas Sensors

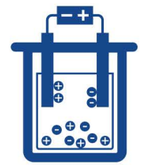
Liquid Evaporator

HYDROGENATION

& Dehydrogenation

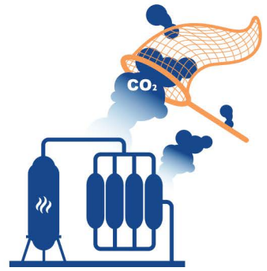


Toluene Feed-Stock

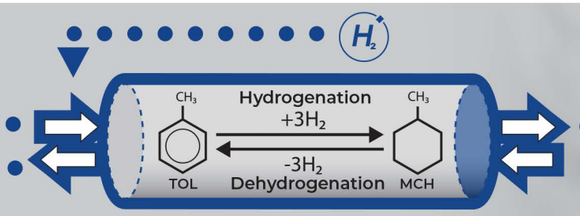


Electrolysis

Biomass

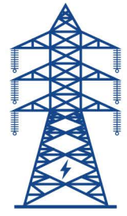


Steam Reforming



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

Chemical Industry



Power Generation

Heating

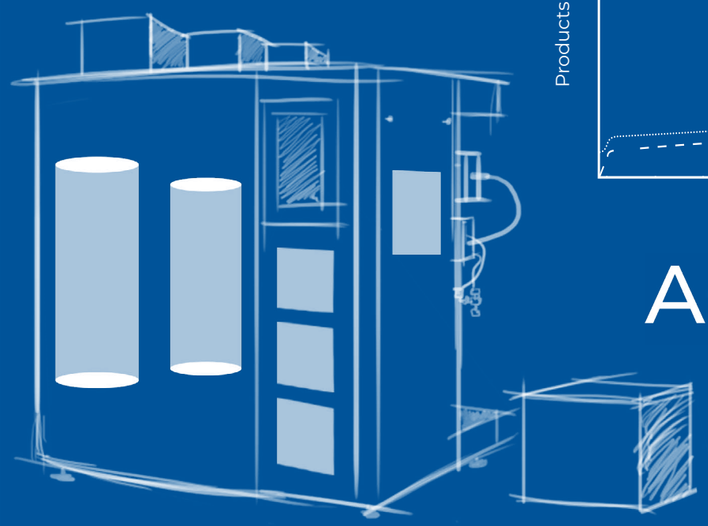
Fuel Cells

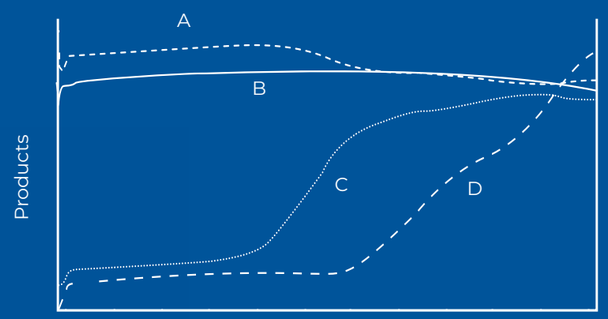
Sustainable Aviation Fuel

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.

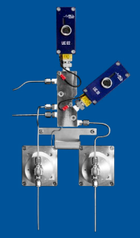




$$A+B \rightleftharpoons_{CATALYST} C+D$$

Dozens of options

High Resolution Pressure Valve



L/L/G Seperator

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 cataylst characterization for the Flow Reactor to understand the effects of reaction conditions on critical parameters.

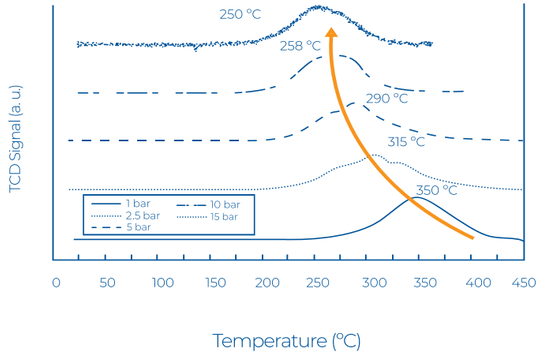
- Characterization without the need to remove the catalyst from the reactor.
- Use of TPR, TPD, TPO, as well as Pulse Chemisorption.
- Analysis can be performed both before and after the reaction.
- High pressure capabilities.

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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