BenchCATs for Biofuels

Lab and Bench-Scale Systems for Biofuel and Sustainable R&D

INTRODUCTION

"Complete Chemisorption & Reactor Solutions—Precision Without the Premium"

AMI has extensive experience in the design and construction of **BenchCAT** reactors for biofuel applications. The study of biofuel processes has become a significant area of research in recent years. Although still largely in the research stage, substantial progress is being made, making the development of a commercial process likely in the near future.

Biofuel is a broad term referring to any fuel not derived from fossil sources. In its simplest form, it can be ethanol produced from sugarcane or corn via fermentation. However, alcohol-based fuels lack the energy density of conventional fossil fuels like gasoline or diesel. Current efforts are focused on developing biofuels that closely resemble gasoline or diesel in their properties and performance.

Biofuels can be derived from various sources, including municipal waste, wood chips, soybeans, and algae. Depending on the source, a different process and thus different reactor design and conditions are used. Below we explore three processes for the production of biofuels in which AMI has participated with a **BenchCAT** reactor design and construction.

Via Gasification of Biomass

The Fischer-Tropsch (F-T) process is perhaps the oldest and most well-known method for producing synthetic fuels[1]. The original process was developed in the 1920s and 1930s and was commercialized in Germany by the late 1930s.The F-T process was to produce fuel for both automobiles and military equipment.

The F-T process can be utilized to generate biofuels from nearly any carbon-containing biomass, including municipal waste, wood chips, celluloid grasses, and more. The first step in such a process is the gasification of the biomass to form Syngas (H_2+CO). This Syngas is then converted into hydrocarbons through the F-T process using a catalyst, typically iron or cobalt. By carefully controlling key process parameters -such as temperature, pressure, ratio of H_2 to CO-the product composition can be controlled. The F-T process can yield a wide range of hydrocarbons, from light gases to heavy waxes.

Biomass -> Gasification -> Syngas -> F-T -> Fuel

Figure 1 illustrates a typical F-T **BenchCAT** reactor designed by AMI. The four gases include hydrogen and carbon monoxide (Syngas), nitrogen as a diluent, and argon as an internal standard for analysis. The reactor is designed to operate at temperatures up to 400°C and pressures up to 1,500 psig, although typical operating conditions are lower. The system includes three separators to facilitate product collection:

1. The first separator, maintained at approximately 150°C, collects heavier products, such as waxes.
2. The second separator, set at 80°C, captures mid-range hydrocarbons and some water.
3. The third separator, kept at room temperature, collects lower-end hydrocarbons along with a significant amount of water.
   All separation processes occur at the reactor's operating pressure, ensuring efficient product recovery.

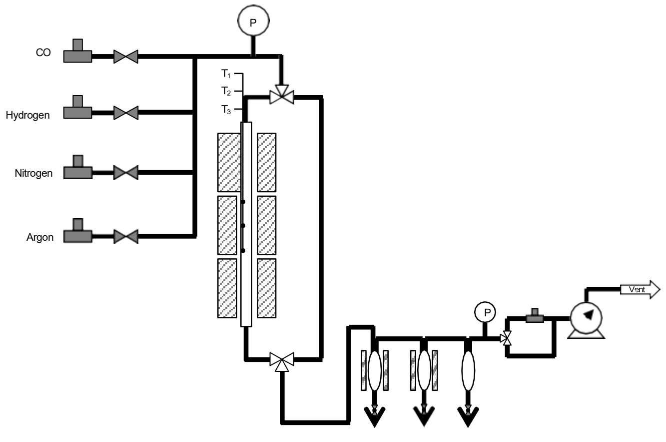

Figure 1. Schematic of typical F-T BenchCAT reactor.

From Alcohols

As previously discussed, alcohols can be classified as biofuels, though they possess a lower energy density compared to conventional hydrocarbon fuels. Alcohols are readily synthesized through the fermentation of sugar- or starch-rich biomass. They then can be converted to more conventional fuels via catalytic condensation processes. For example, a gasoline range product can be obtained by reacting lower chain alcohols over a zeolite, such as ZSM-5[2] whereas higher range products can be obtained using base catalyzed aldol condensation[3].

Starch-Containing Material -> Alcohols -> Condensation-> Fuel

These processes can be conducted in a more-or-less conventional fixed bed reactor. Figure 2 depicts such a reactor that could be used for alcohol condensation. A pump is used to feed the liquid alcohols and both the gas and the liquid feed pass through preheaters prior to entering the reactor. A heat exchanger and gas-liquid separator are in the high-pressure zone. Gas products flow out from the top of the separator while the liquid products are withdrawn from the bottom. Level sensing and automatic valves can be used to fully automate the process.

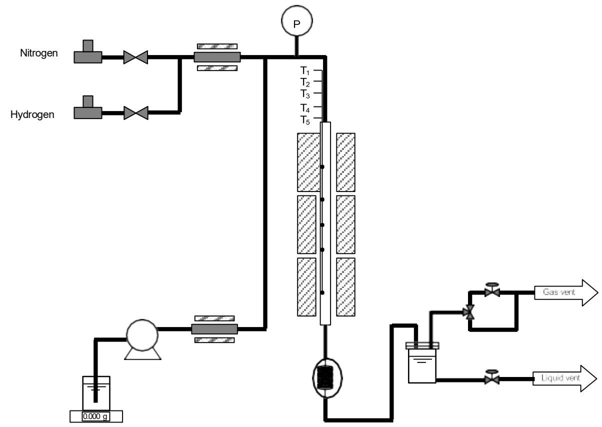

Figure 2. Schematic of ***BenchCAT*** *reactor suitable for studies*

Via Trans-Esterification

Biofuels can also be produced by trans-esterification of oils or lipids with a simple alcohol such as methanol. This reaction has been reported using various sources of lipids, such as rapeseed oil, soybean oil, used vegetable oil, and algae oil. In a catalytic reaction, the catalyst is a base, typically NaOH. The reaction can also be carried out in the presence or absence of a catalyst at supercritical conditions[4].

Bio-Oil -> Catalytic or Supercritical Reaction with Methanol -> Fuel

Figure 3 is a schematic of a reactor that can be used for both catalytic and supercritical esterification of oils.

Figure 4 (back page) shows a photograph of the reactor. This particular reactor is rated at 350°C and 350 bar (ca. 5200 psig) or 700°C at room temperature. The higher temperature rating is used to pretreat the catalyst. The tubular reactor is constructed of Inconel metal in order to achieve these dual conditions. Note that in this reactor the pressure reduction occurs before the product collection.

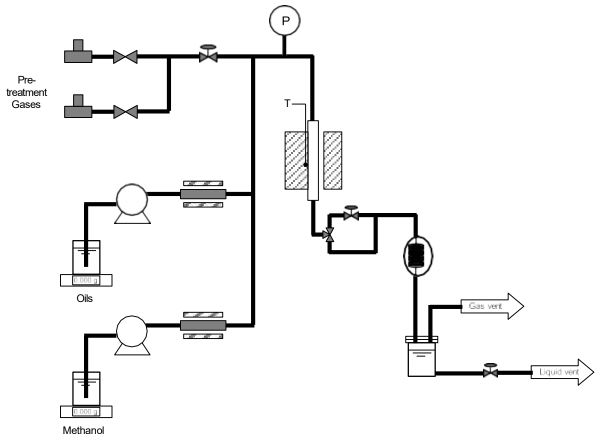

Figure 3. Schematic of ***BenchCAT*** *reactor for supercritical trans esterification of lipids.*

Figure 4. ***BenchCAT*** *reactor for supercritical trans-esterification of lipids.*

In summary, no matter what your specifications are for automated, research-quality reactors, AMI has the technical and scientific expertise to meet your needs. We have extensive experience in the fields of catalytic science, catalyst characterization, and reactions. These descriptions of **BenchCAT** reactors suitable for biofuel research are one example of this experience.

1. *For a summary of the F-Tprocess see, for example: www.fischer-tropsch.org/primary_documents/presentations/acs2001_chicago/chic_slide01.htm*
2. *C.D. Chang, Methanol to Gasoline and Olefins, Chemical Industries, 57, p. 133 (1994).*
3. *www.virent.com/BioForming/Virent_Technology_Whitepaper.pdf*
4. *S. Saka and D. Kusdiana , Biodiesel Fuel from Rapeseed Oil As Prepared in Supercritical Methanol, Fuel, 80, p. 225 (2001)*