

August 3, 2011

Syngas-to-Distillates: Evaluation of a New Process to Produce Hydrocarbons from Synthesis Gas

Utilization of whole biomass to produce fuels and chemicals can be achieved in several ways, one of which begins with gasification. Once biomass is gasified, the resulting mixture of CO, CO₂, H₂, and H₂O – known as synthesis gas or “syngas” – can be converted to fuels and chemicals via several different routes. One of these routes, known as methanol-to-gasoline, or MTG, begins with the production of methanol from syngas and proceeds to convert this methanol to dimethyl ether (DME) and eventually to a hydrocarbon mixture very much similar to petroleum-derived gasoline. This multi-step process has been demonstrated and even commercialized, but it has not gained a long-term foothold in the fuels market due to capital and operating costs. The Syngas-to-Distillates (S2D) team is examining how to reduce these costs by transforming this multi-step process to a single-step process, as depicted in Figure 1.

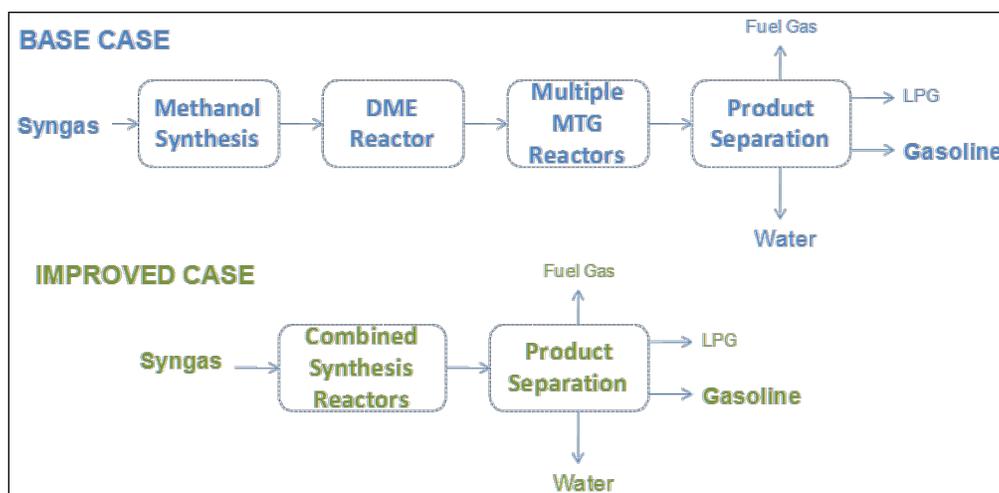


Figure 1. Process models for the S2D base-case and combined or “improved-case” processes

We previously reported how the team is approaching this problem through a combination of techno-economic modeling and laboratory-scale experiments. The techno-economic modeling efforts revealed that a single-step process has potential to out-perform the conventional approach in terms of capital and operating costs (i.e., net fuel production cost), but requires a certain level of performance in converting syngas to distillates in the single-step catalyst bed. Over the past several months, the team has used laboratory results to update the modeling effort, leading to realistic predictions of what the single-step process might achieve.

Because the single-step process involves several synthetic steps in one catalyst bed, the likelihood of undesirable side reactions is increased. As a result, a balance of catalyst composition and operating conditions is required to reduce the production of undesirable products like CO₂, CH₄, and C₂H₆ while maximizing the production of liquid hydrocarbons in the C₅+ range.

The team developed an improved methanol/DME synthesis catalyst that suppresses CH₄ and CO₂ production in the initial conversion of syngas, increasing the yield to the intermediates methanol and DME, which can then be further converted to liquid hydrocarbons. Utilization of this improved catalyst increased the yield in the single-step catalyst bed.

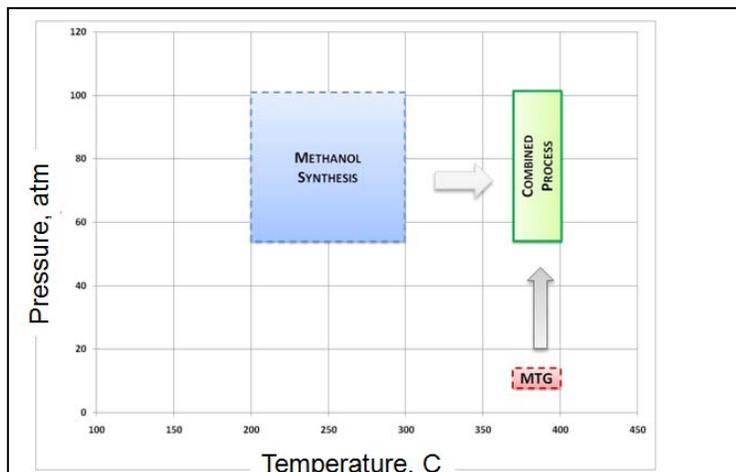


Figure 2. Pressure and temperature considerations in combining methanol synthesis and MTG operations in a single bed



Figure 3. Example of liquid product from the S2D test stand

Additional work resulted in identification of improved operating conditions relative to the initial work, which was conducted at 1,000 psig and 375°C (see green box of Figure 2). These improvements in operating conditions and methanol synthesis catalyst resulted in increased yield of liquid hydrocarbons, but not to the level required to make the techno-economic argument against standard MTG processing.

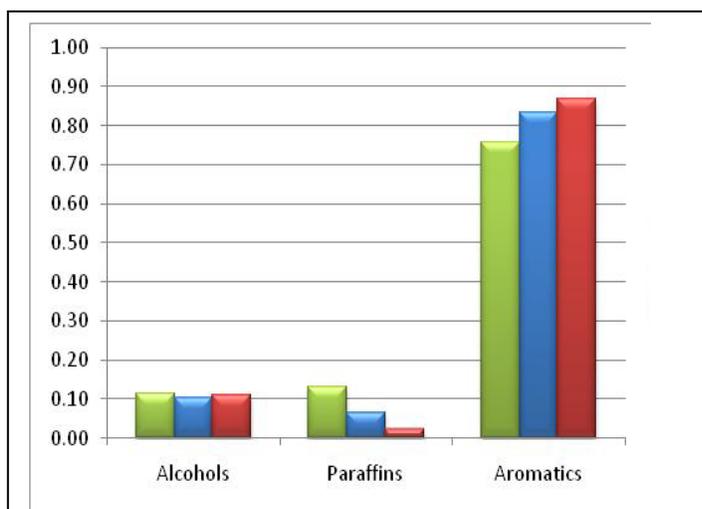


Figure 4. Typical liquid hydrocarbon composition from the S2D process at three different pressures

The single-step process results in a colorless two-phase liquid product, as shown in Figure 3, with the upper phase containing the liquid hydrocarbon mixture and the lower phase containing mainly water (byproduct) and some unreacted oxygenates (methanol, etc.). The mixture is analyzed by GC-MS to determine the hydrocarbon composition, product selectivity, and process yield.

At a high level, the composition of the hydrocarbon liquid is shown in Figure 4. Additional optimization work may lead to further improved yields, making the process more competitive and bringing it closer to potential pilot demonstration.

The S2D team consists of NABC members from PNNL, NREL, Albemarle, Pall Corporation, Tesoro, and BP Products, NA.