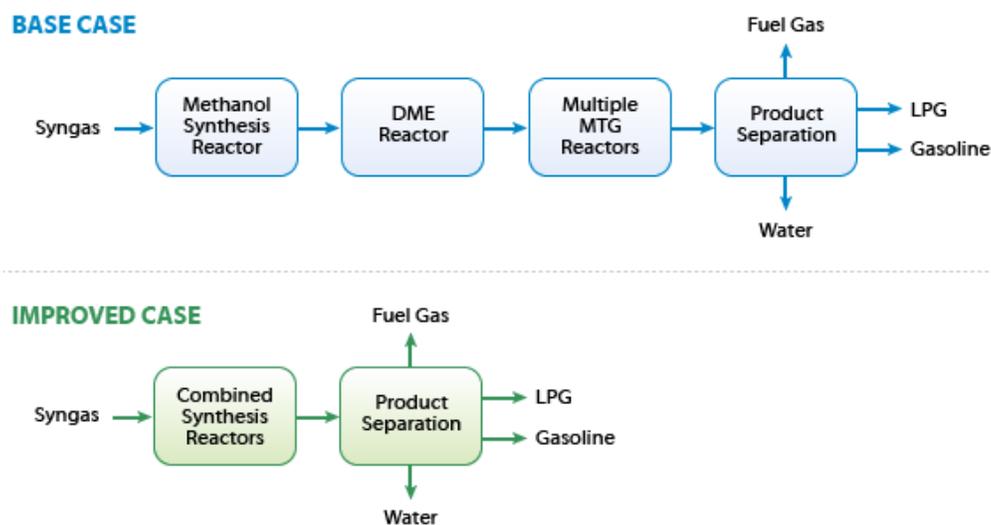


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## Syngas to Distillates: Evaluating a New Process to Produce Hydrocarbons from Synthesis Gas

A major research goal of the National Advanced Biofuels Consortium (NABC) is to develop improved methods for producing high-value intermediates that can be transformed into hydrocarbon fuels. The syngas to distillates (S2D) team is examining how to reduce the capital and operating costs of using a methanol-to-gasoline process, as depicted in Figure 1, to convert synthesis gas (syngas), which is composed of carbon monoxide and hydrogen, to hydrocarbon fuels.



**Figure 1. Process flow diagrams for the S2D base case and the combined or “improved case”**

The S2D team is examining how combining two synthesis steps might lead to the desired goals. The effort requires that we first understand the process design for the base-case and improved-case processes. In the base-case process, syngas is 1) converted to methanol, 2) dehydrated to dimethyl ether (DME), 3) oligomerized, and 4) further dehydrated to the final hydrocarbon mixture. In the improved-case process, methanol/DME synthesis is coupled with conversion to hydrocarbons in a single reactor as shown in Figure 1.

One challenge the team faces is combining process steps that typically are done under very different reaction conditions. For example, methanol synthesis in the improved-case process occurs at a significantly higher temperature than what is used for the base-case process and requires a catalyst that is stable to sintering at the elevated temperature. The pressure and temperature requirements for the improved-case process are shown in Figure 2. In addition, at the pressure and temperature required for the improved-case process, the methanol conversion catalyst must be stable in the presence of water that is formed during the reaction.

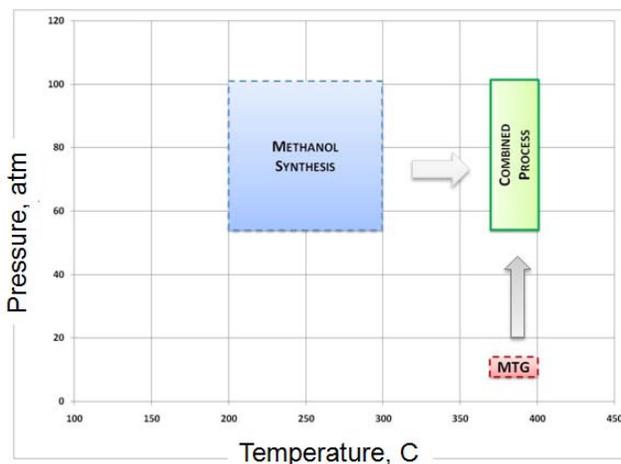
If the potential reduction in cost (both capital and operating costs) of the combined process is favorable, the quality of the product, which consists of liquefied petroleum gas and liquid hydrocarbons, must be determined. If the product quality is confirmed, the goal would shift to determining whether the combined catalyst system is stable under the process reaction conditions and whether mitigation strategies would be required.

In recent work, the team primarily has been involved in refining the process models and studying the reactor parameters. In an effort to refine the process models, team members from Pacific Northwest National Laboratory (PNNL) and the National Renewable Energy Laboratory (NREL) met to evaluate the models being developed. PNNL completed a new Case-1 (one-step) performance model that currently is being reviewed by the analysis team.

For parametric testing, the team has focused on determining the effect of reducing the reactor pressure in the improved-case process. In addition, experimental work that will help define the methanol synthesis parameters has been initiated. Pressure studies were performed under high-, medium-, and low-pressure conditions, with all other parameters, including temperature, space velocity, bed configuration, and syngas composition, held constant. The product mixture was primarily in the C<sub>10</sub> to C<sub>12</sub> range and consisted of aromatics (major components), paraffins, and alcohols (less than 10%). Interestingly, the aromatic content increased as the reactor pressure decreased. The team is getting closer to understanding the expected product mixtures of both the liquids and gases produced. The results suggest that changes, including catalyst changes, will need to be incorporated during later tests. The revised process baseline model will be key to helping us evaluate whether the process can be operated economically.

Based on updated performance data and information from our models, the team will continue to define the process economics for the base-case and the improved-case processes. Further refinements based on comments from the analysis team will be incorporated into the one-step base-case process model. For the parametric analysis, pressure studies will be completed; catalyst changes, including ratios of the catalyst in the bed, will be evaluated; and gas compositions will be studied.

The S2D team consists of NABC members from PNNL, NREL, Albemarle Corporation, Pall Corporation, Tesoro Companies Inc., and BP Products North America.



**Figure 1. Pressure and temperature requirements for the improved-case process**