Liquid Fuels from Gases and Role of Catalysts

B. Chehroudi, PhD

Many countries in the world, for example in Middle East geographic area, have large resources of natural gas but little local market and no pipeline infrastructure to ship it to larger economies. Gas-to-liquid (GTL) process can convert natural gas into liquid form that is much easier to export. For precisely the same reason, such countries crack ethane to produce ethylene and convert that into polyethylene, ethylene glycol, and other petrochemicals. Also, that is why they convert methane into methanol and liquefied natural gas (LNG). The GTL not only would allow these countries to participate in the larger diesel fuel market, but also address the environmental regulations calling for the type of low-sulfur diesel fuels emerging from this process.

The GTL process begins with synthesis gas (or syngas) production. At the front of the plant there is a reformer or a gasifier to convert natural gas into carbon monoxide and hydrogen. This part of the process is similar to processes used for years to produce ammonia and methanol. This syngas is then fed to a *Fischer-Tropsch* reactor. The Fischer-Tropsch process developed in Germany during 1930s, uses steam and oxygen to produce coal gas, which was then liquefied by a catalytic reaction. The Fischer-Tropsch process was used to manufacture nearly 600,000 metric tons of synthetic coal fuels each year during World War II (1939 – 1945). The syngas thus produced, is then fed into a Fischer-Tropsch reactor, which converts it into paraffin wax and subsequently is hydrocracked to make a potpourri of products, largely diesel, but also some naphtha, lub-oil base stocks, and gases. The novelty here is in the Fischer-Tropsch, being at the core of the process.

Critical to and enabler of the Fischer-Tropsch process are the catalysts. This is where all the technology providers perform a lot of research to distinguish themselves and gain the highest yield. Catalyst manufacturers are very secretive about the details of their formulations, however, the latest generation of catalysts in Fischer-Tropsch process are based on cobalt, usually on alumina supports mostly combined with precious metal promoters. Iron has also been used, particularly at high temperatures and when the feedstock contains a lot of impurities such as sulfur and it produces aromatics, oxides, and other nonparaffins. Whereas cobalt is very efficient (high activity and selectivity) in making paraffins from relatively clean feedstock. The other important component of the process is the way the catalyst bed is designed and operated. They are generally categorized as slurry or moving-bed and fixed-bed processes. In the slurry-phase bubble column reactor, considered the primary choice for the newer Fischer-Tropsch processes using cobalt, syngas is bubbled up through a slurry made up of hydrocarbon wax, liquid at the reaction conditions, and the catalyst suspended in it. In this case, catalyst is constantly being replenished as it is lost.

One of the main reasons GTL is at the spotlight of the large-scale commercialization is the fact that the cost of production is coming down. Better catalysts are a large part of the drop in GTL technology costs. Reducing precious metal or cobalt contents is a way catalyst companies can reduce costs. *Economy of scale* has also been an important aspect of price reduction for the GTL process. In summary, if the right location exists and the right access to gas is available, GTL can be economical. Precisely for this reason intense activities is seen on building plants today. South Africa's company Sasol, Shell, ExxonMobile, British Petroleum, and catalysts companies are all in synergistic joint ventures regarding the large-scale plants based on the gas-to-liquid process. For example, a collaboration between Royal Dutch/Shell, Daimler-Chrysler, and local bus company recently revealed a bus powered by diesel fuel derived from the GTL process.