Creating new paths for coal and gas to liquids production

For more than 30 years, the oil majors have been exploring ways to add value to gas stranded in remote locations. If a market is not close to hand, the gas has little to no value and can even become a problem if it has to be reinjected or flared.

The search for selectivity

The chemistry of light alkanes, such as methane and ethane (most abundant in stranded gas), is rather unselective, due to the symmetry of the molecules and the nature of the carbon -hydrogen bonds. Finding ways to induce selectivity has been a major challenge in finding a way to produce useful products from this valuable resource.

Research into the selective transformation of methane into liquid fuel products has taken some very creative approaches over the years, ranging from plasma-induced pyrolysis to light olefins; fuel-rich combustion, both catalytic and non-catalytic, to mixtures of carbon oxides, hydrogen and light olefins; radical-induced direct synthesis to methanol; oxidative coupling to light olefins over non-stoichiometric oxides; and transformations using halogens and even sulphur to initiate selective activation.

Narrowing the focus

From these ongoing efforts, a consensus has emerged that routes involving the production of synthesis gas (syngas; a mixture of carbon monoxide and hydrogen) are the only economically viable ways of converting methane to liquid fuels. The preferred processes involve the conversion of syngas to long-chain hydrocarbons in the so-called Fischer Tropsch (F–T) reaction. In fact, F–T chemistry was first developed and used by the Germans to produce synthetic fuels during World War II, and later by SASOL to produce synthetic fuels from coal (CTL) in a sanction-blocked South Africa. Subsequently, Shell took a first bold step to put a small gas to liquid (GTL) plant on the ground in Bintulu, Malaysia, using a fixed-bed F–T process utilizing a supported cobalt catalyst.

GTL has recently gained a new lease on life, with the advent of US$ 50/bbl oil and a thirst for environmentally clean and friendly products—GTL processes yield zero sulphur, high cetane diesel. Some very significant projects have been announced, particularly in Qatar. In the future, we will see others in the Mid-East and elsewhere. Coal to liquids will follow where that resource is abundant, as in China and the USA.

Identifying opportunities for success

Conventional CTL/GTL processes utilize three stages: syngas generation, hydrocarbon synthesis, and product upgrading (mild hydrocracking or hydroisomerization). The first stage is by far the most capital intensive and offers the best chance to significantly improve the economics. The catalysis is relatively simple but presents significant challenges in terms of thermal and mechanical stability. Reactor engineering to maximize thermal efficiency in a compact design has been the key challenge.

The third stage utilizes variations on well-known catalyst systems, but there is much to be gained by tailoring the catalysis to maximize yield in the product slate of choice, and this continues to be a major subject of research by Albemarle and others.

Since Shell's first demonstration of a process utilizing a multi-tubular, fixed-bed F–T reactor, technology for the second stage has been further advanced to slurry bubble columns of various designs. These allow more heat removal and thus higher conversion over more active catalysts than their predecessors. The challenge for catalyst design is now one of achieving even more activity and selectivity while maintaining life and mechanical integrity under reaction conditions and facilitating regenerability to further aid longevity.

A source for effective solutions

In spite of the high capital investment needed, the economics of CTL/GTL processes are favourable. Clearly, continued advances in reactor engineering, separations science and catalysis will be required to enable more widespread use of these technologies. Albemarle Catalysts has been active in this field for quite a number of years and GTL/CTL is now one of the largest R&D projects within Albemarle. Albemarle Catalysts will continue to contribute to this effort, supplying innovative solutions and advanced catalytic products to CTL/GTL technology providers worldwide.

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