Ethane’s reign as cost-advantaged feedstock for steam crackers leaves market hungry for propylene

HOUSTON (July 11, 2017) -- A class of propylene production technologies designed to produce more “on-purpose” propylene -- a chemical essential for plastics production -- has emerged as the market cornerstone and global price setter for the propylene market, according to new research from IHS Markit (Nasdaq: INFO), a world leader in critical information, analytics and solutions.

Steam crackers and oil refineries, once the traditional sources of propylene as a derivative or co-product of crude oil processing, no longer yield the supply of propylene the market requires due to a shift in feedstocks from naphtha (derived from crude oil) to ethane (derived from natural gas), primarily in North America. To meet the forecasted increasing market demand for propylene, chemical producers have turned to chemical engineers and chemists to develop -- and relatively recently -- commercialize, so-called “on-purpose” propylene production technologies (technologies designed to produce propylene as the sole product versus propylene as an alternative or co-product).

The North American shift to ethane-based crackers, which produce very low yields of propylene, will continue to accelerate the shortfall in propylene volumes derived as a co-product from traditional sources for the next five years at least. According to the IHS Markit forecast, the need for on-purpose propylene production will continue to escalate.

“The market is hungry for adequate sources of propylene supply and is investing in technologies that will deliver that supply,” said Don Bari, vice president of IHS Markit and lead author of the IHS Markit report and supporting analytics, “Competitive Processes and Cost Tracker (CPCT)—On-Purpose Propylene Production.” The IHS Markit propylene process report assesses the technical and economic merits and challenges of the various on-purpose technologies.

While Bari acknowledges that ethane feedstocks are providing significant cost advantages for producers with U.S. plants, the cost advantages are not without trade-offs for the petrochemical and polymers industries as a whole. For example, the ability to maintain an adequate supply of propylene has been one of those tradeoffs. “Fortunately, the industry is very technologically driven—we’re problem solvers by nature, so companies are willing to invest in new and emerging technologies to find viable solutions,” Bari said.

“Our IHS Markit research sought to examine the strengths and benefits from a technical and regional economic perspective, of the six on-purpose propylene production technologies currently gaining traction in the commercial marketplace,” Bari said.

The six principal propylene on-purpose technologies assessed by the IHS Markit report include propane dehydrogenation (PDH); coal-to-olefins/coal-to-propylene (CTO/CTP); methanol-to-olefins/methanol-to-propylene (MTO/MTP); gas-to-olefins (GTO); metathesis; and high-severity fluidized catalytic cracking (HS-FCC). Each of these processes uses a different feedstock and has advantages and challenges that differentiate them.
PDH units dominate the global market, Bari said, with about 40 percent of the global on-purpose propylene capacity today, and stakeholders for those facilities expect they will remain competitive due to attractive propane feedstock cost and abundant supply in/from the U.S.

“Nevertheless, the challenge is that when companies invest in process technologies, they are making multi-billion dollar investments, which must be sustainable for a 30-year period,” Bari said. “During that time, market conditions, feedstock prices and availability will vary, often significantly, so companies really want to be able to interrogate the cost data against a host of variables over time, to minimize investment risk.”

With that in mind, Bari said, he and his fellow researchers used the company’s CPCT analytical model to assess the multiple on-purpose technologies over nearly a 20-year period, which accounted for a large fluctuation in feedstock prices. “When we assessed the various technologies over time and at many different feedstock prices represented during the past 16 years, we found that the PDH process would have been the most economically competitive in the U.S.,” Bari said. “For example, since the year 2000, we estimate that PDH would have had an average production cost (including depreciation) of production advantage over naphtha cracking of U.S. $405 per metric ton (with feedstock and co-products taken at market price); but a metathesis-based plant would have had an average U.S. $47 per metric ton disadvantage over naphtha-cracker-based propylene.”

Moreover, the IHS Markit report said, a hypothetical GTP facility also would have been at an advantage over a naphtha-based technology, by U.S. $202 per metric ton, on average. An interesting aspect for the GTP route is that, according to IHS Markit, estimates for the four-year period of fourth-quarter 2010 to third-quarter 2014, GTP-based propylene production was the most competitive on-purpose propylene technology. The process delivered an estimated U.S. $215 per metric ton production cost advantage over the PDH route.

“So a time-based analysis is a very critical part of the technology selection, which is also exemplified by the propylene production technology situation in China; a different and more complex story than in many other parts of the world,” Bari said. “China is in a very deep propylene monomer and derivatives-deficit position. Therefore, during the last decade, China has developed and deployed on-purpose propylene in significant volumes based on technology that takes advantage of its indigenous low-cost coal.”

According to the IHS Markit analysis, during the three-year period of fourth-quarter 2005 to third-quarter 2008, and then again in the four-year period of first-quarter 2011 to fourth-quarter 2014, coal-based technology, on average, (based on North China coal prices) had a $100 per metric ton production cost advantage over the PDH route (See figure). Owing to this advantage is the low and relatively stable price of coal as compared to very cyclical (and imported propane), especially during 2011 to 2015, where PDH raw material costs (per ton propylene manufactured) have moved from U.S. $420 up to U.S. $1,060 but most recently, declining rapidly to U.S. $309. The CTP raw material costs by contrast, have moved in a relatively flat range of U.S. $140 to U.S. $360 per ton of propylene in the same period.

For the MTP process (with methanol at market prices), raw material costs are estimated to have been continually higher than for the PDH route, but generally tracking that of PDH raw material costs.

However, in contrast to very competitive raw material cost for Chinese coal-to-propylene technology, the technology comes with investment, logistical and sustainability challenges. Specifically, these processes are very capital intensive (e.g., require five times the capital investment to construct as compared to a PDH plant). In addition, coal transport costs are an issue since Chinese coal fields sit in central China, while the consumers of propylene derivatives sit predominantly on the east coast, where PDH plants are located. In terms of sustainability challenges, coal-based propylene plants have a low-carbon efficiency (i.e., resulting in relatively high carbon emissions), and have very high water consumption, which is problematic, especially in arid climates.

MTO/MTP in China had high financial expectations when the first wave of investments were made ahead of the crude oil crash in 2014/2015, but now the future competitiveness is questionable as methanol (market) prices have becoming unattractive in China due to the drop in crude-to-gas spreads and attractive alternative uses for methanol. (Although there are exceptions where methanol feedstock can be acquired at below-market costs.)

“Perhaps, once all is considered, particularly giving weighting to the importance of access to inexpensive feedstocks, which is a majority of the cost for on-purpose production, PDH is favored in nearly all regions, with the exception of China. In China, the on-purpose technology relative competitiveness varies, largely due to feedstock dynamics, as demonstrated using our analytical model,” Bari said. “It must also be noted that, even with its fairly rapid commercial success, PDH is still a relatively young technology and have been plagued with operations stability issues, due to the complexity of the reactor-control systems. Moreover, new licensors are continuing to introduce “improved” PDH processes, which are discussed in greater detail in our report.”

To speak with Don Bari, please contact Melissa Manning at melissa.manning@ihsmarkit.com. For more
information about the IHS Markit report and supporting analytics dataset—“Competitive Processes and Cost Tracker (CPCT)—On-Purpose Propylene Production,” please contact stacy-ann.wilson@ihsmarkit.com.

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