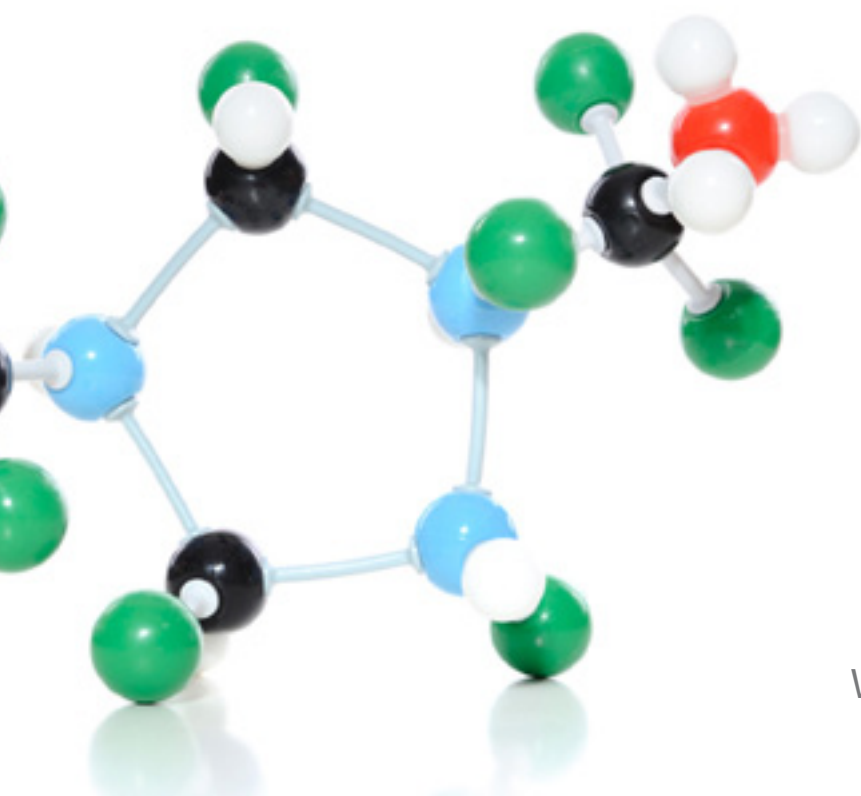


SPECIAL REPORT: PETROCHEMICALS

Lighter feeds in US steam crackers brings new attitude toward on-purpose butadiene, propylene prospects

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By Jim Foster, Senior Editor, Petrochemical Analytics, Platts



Olefin production in the United States is undergoing a step change as lighter feedstocks from the numerous North American shale gas plays make their way into the feedstock slate. Inexpensive NGLs are pushing heavier naphtha feedstocks to the side. And some in the markets are touting these developments as a renaissance for the US petrochemical industry.

Yet while the renaissance certainly does appear to be underway, not everyone is raising a glass and toasting the growing influence abundant ethane is having in the US olefins markets.

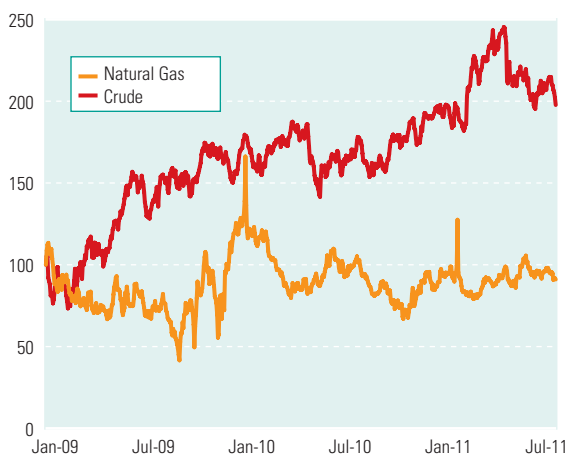
Butadiene buyers have recently faced record-high prices – when they were actually able to find any material in the perpetually-tight spot market. Propylene prices have climbed so high the US export market for polypropylene has been decimated. And even those who could benefit the most from a switch to lighter feedstocks could see margins shrink as ethane prices decouple from natural gas.

NATURAL GAS DECOUPLES FROM CRUDE OIL

The abundance of shale gas in the United States has caused natural gas prices to decouple from crude (see chart below). The prices in the chart have been normalized to 100 as of the start of 2009. Since that time, the natural gas price (shown in orange) has trended mostly lower, with a couple of seasonal spikes in the winters of 2010 and 2011. During that same period, though, the crude price has been trending higher.

That decoupled relationship between crude and natural gas has pushed olefins producers in the US to natural gas as preferred feedstock. Historically, US crackers used 70% ethane feedstock and 30% naphtha, according to a report by Chemical Market Resources Inc. The shale gas plays have changed the feedstock dynamics to 87% ethane and 13% naphtha. That change in feedstocks has reduced propylene production in crackers by more than 50%. It has also tightened supplies of crude-C4s and butadiene in the US.

1) Natural gas decouples from crude oil



Each product's price has been normalized to 100 as of January 1, 2009 to better illustrate the relationships between the products. The prices do not represent the actual dollar value.

Source: Platts

BUTADIENE PRICES RESPOND TO MARKET TIGHTNESS

The effect tightening butadiene supplies have had on the US markets is evident in the pricing. The US spot butadiene price climbed to record highs in June of this year. (see chart 2), nearly \$2,000/mt (about 60%) above the previous record high price set during the energy run-up of 2008.

The situation was similar around the globe, with both Asian and European butadiene prices hitting record levels as supplies tightened. At the time, the tight butadiene supplies were exacerbated by a significant run-up in the price of natural rubber, boosting demand for synthetic rubber downstream.

Even with that higher demand, US butadiene derivative production has been scaled back because of a lack of feedstock. One US butadiene buyer estimated the amount of butadiene being consumed in the US at just over 1.8 million mt annually.

"That's what we're using because that's what is available to use," the source said. "What would the demand be if there was more material available? I don't know. The [butadiene] derivative rate in the US is near 60% now. In the past we've run at 70%. There's a chance that those derivative rates would climb 10 percentage points if there was more material available."

His estimate puts the total butadiene consumption capacity in the US near 3 million mt annually. A 70% derivative rate would put US butadiene demand near 2.15 million mt annually – about 300,000 mt below what currently is available.

Since reaching the record highs in June, global butadiene prices have been correcting lower – though most market participants said they expect butadiene supplies to be perpetually high – and prices to remain relatively strong when compared to historic norms – because of the shifting feedstocks in the US.

With US butadiene consumers facing perpetually high prices, production options once thought unprofitable are starting to be discussed. In August TPC Group announced it was performing a detailed engineering study of on-purpose butadiene production.

"We have a 50-year history of commercial production of on-purpose butadiene and are well positioned to bring the needed additional butadiene to the marketplace," Michael Bloesch, TPC's vice president of strategic initiatives said. "Customers have expressed a strong interest for this project, which provides long-term security of supply of a critical product to meet their growing business needs."

TPC's plan would utilize an existing idled dehydrogenation unit at the company's Houston plant. The unit would use normal butane as the primary feedstock. Normal butane is a natural gas liquid found in the US shale gas plays, which could provide an abundant, low-cost feedstock for the plant.

One US-based butadiene trader, though, said the process could be expensive.

"The problem is it costs a lot," he said of on-purpose butadiene production. "It takes a lot of butane – about 2 pounds for each pound of butadiene. But if butane prices fall because of shale gas, this is possible."

The butane from the shale gas, though, is what is enabling TPC to consider this project, Bloesch said in an interview following the announcement of the engineering study.

"The shale plays are not only incentives for crackers to crack light, but also [incentives for] on-purpose production of former co-products," Bloesch said.

"The price of butane is something we are keeping our eyes on."

Butane can be used in gasoline blending, Bloesch said. But there could be less demand for butane to that route, resulting in more on-purpose butadiene feedstock.

"We see likely less gasoline blending in the future," Bloesch said. "That makes the natural home for butane as a cracker feed, for exports or for our process."

The cracker feed option for butane is less likely in the current low-cost ethane environment, making exports or converting butane domestically more likely.

"On purpose [butadiene] as we envision it will supply volumes people need or want [domestically]," Bloesch said. "We see definite demand from our customer base."

The TPC project will produce 600 million pounds (272,158 mt) of material, and will be able to be expanded in the future if demand increases, Bloesch said. The report on the feasibility of the project is expected to be completed in early 2012.

There also is a possibility that butadiene demand in the US may not recover to historically normal levels, a butadiene trader said.

"Demand destruction is real in the butadiene market," he said. "Tire plant closures are a concern."

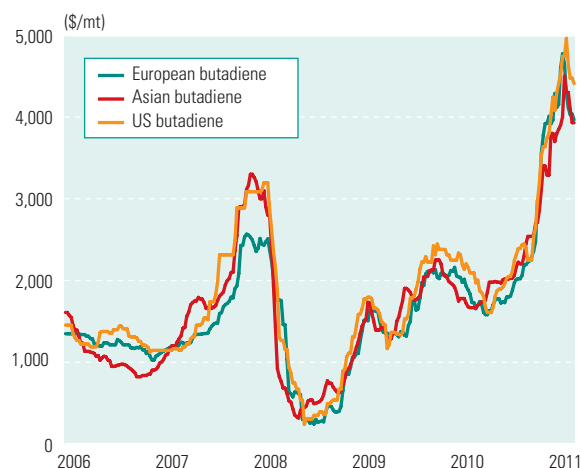
Some of the butadiene demand also is being eroded by recycling, he added.

"A lot of [the demand destruction] is in efficiencies in the regrind market," he said. "Butadiene at \$4,000 a ton is a real incentive for regrind."

He also said he has seen ABS producers losing market share to polystyrene and EPS. And there has been a drop in butadiene going into the SBL (latex) market.

"We hear of it, but we have not seen it," Bloesch said of demand destruction. ABS has the most substitutions and SBL might suffer if there is a drop-off in paper coating. But SBR and PBR do not have many substitutions, Bloesch said.

2) Global butadiene prices



Source: Platts

FOREIGN MARKETS MAY FILL US BUTADIENE NEED

Another possible source for butadiene would be foreign markets, said Robert Bauman, a consultant with Polymer Consulting International.

"South Korea is known for its exports. If I were in Korea, I'd be looking at what shortages there will be in the US and focus on those," Bauman said.

As butadiene prices in the US climb, Korean polyethylene producers could be faced with limited export opportunities to Latin America, Bauman said. The switch to lighter feedstocks – the reason for the tightening butadiene supply – will result in a dramatic increase in ethylene production.

According to the CMR report, nearly 4 million mt of ethylene production has been announced in response to the shale gas plays. These include 1 million mt for Braskem in Mexico, 1 million mt from a new Dow cracker, about 900,000 mt from NOVA in Canada, 450,000 mt from an expansion at Formosa Plastics, 300,000 mt from Dow restarting a St. James cracker and 230,000 mt from debottlenecking at Westlake.

There also is the potential for three new crackers to bring the total of new ethylene capacity in the US to 7 million mt/year, according to the CMR report. US domestic demand for ethylene derivatives was just below 32 million mt in 2010 with nearly 4,845,000 mt (14%) exported, according to the report.

By 2016, that demand is expected to climb to 39.3 million mt. "There is enough capacity to meet domestic demand and still have some exports," according to the CMR report. "Therefore, essentially 100% of the new ethylene capacity will be for derivative exports." When polyethylene in the US gets long the US is expected to dominate the Latin American polyethylene market, Bauman said.

In December, HDPE cargoes moving from South Korea to Chile spiked nearly 300% year on year to 2,296 mt. South Korean producers also moved 667 mt of LDPE and 108 mt of LLDPE to Chile over the same period, compared with none for either grade in December 2009, according to Platts research.

Parcels moving from South Korea to Peru also climbed in December, with 1,723 mt of HDPE exports compared with 123 mt in the same month of 2009. South Korean producers also sold 125 mt of LDPE to Peru in December, compared to none in 2009.

Those opportunities, though, could dry up for Korean exporters as US polyethylene production ramps up during the next three to five years.

"We are going to own that market," a polyethylene trader said.

Instead, Korean producers could cut polyethylene production, and focus on exporting butadiene to the US, Bauman said.

"Korea's strategy could be responding to those shortages in the US," Bauman said. "Most likely, the crude-c4s and other heavies are going to be sourced from outside the US. There's an opportunity there."

As of now, there are no official plans for South Korean producers to increase butadiene production to fill export demand to the US, a US-based butadiene trader said in August. "That certainly is an interesting idea," he said. "I haven't heard of that happening – but it is feasible. But it will depend on how they are committed to C4 and propylene. There certainly is a shortage of C4s globally at this point."

A South Korean butadiene producer, though, said he expects the Asian producers to shift from ethylene to heavier materials as the Latin American opportunities dwindle.

"Korean crackers are no [longer] competitive with C2 and C3 [because of] US and Middle East gas extraction, especially ethylene" the Korean producer said. "[The] polyethylene spread is so poor that many crackers are just expecting compensations from mixed C4 and butadiene."

It's more likely, though, that polymers from Asia will be shipped to the US, he said.

"In my view [Asian producers] will move more butadiene from Korea to the US for a while," he said. "But as time goes on they will find out that to move polymers is more efficient than to move monomers. Butadiene is a gas monomer. Its logistics cost is high, and there is limited shore storage in the US."

TPC's Bloesch, though, said the potential of greater butadiene imports in the US should not stall attempts to produce on-purpose butadiene in the US. "Import quantities are higher than our production rates," Bloesch said.

The proximity of China to petrochemical production in other parts of Asia could possibly absorb some of the material Korea or other Asian countries won't be able to export because of the lighter feeds in the US, Bloesch said. Also, imports will be limited by storage logistical infrastructure bottlenecks, including a lack of storage.

PROPYLENE SHORTAGES ALSO EXPECTED

The shift to lighter feedstocks will also reduce the amount of propylene available in the US markets. According to CMR, the change from 70% NGLs and 30% liquids to 87% NGLs and 13% liquids in

2011 has reduced propylene production in crackers by more than 50%. Also, a larger percentage of propylene is being produced at refineries, which potentially could be diverted into the gasoline pool instead of to petrochemical plants.

The tightness in the US propylene market, relative to the ethylene supply, is illustrated in the growing premium propylene commands over ethylene. (*see chart 3*). Since the start of 2009, there have been only a few brief periods where ethylene prices were higher than propylene.

According to the CMR report, about 1.5 million mt of new propylene capacity will be needed to replace the capacity lost to the NGL shift. At a 3% growth rate for propylene derivatives, another 2 million mt/year of new propylene capacity will be needed to meet 2015 projected propylene derivative demand.

Tightening propylene feedstock could push polypropylene prices high enough to have some consumers consider switching to HDPE for injection molding and thermoforming, and possibly polystyrene and PET for thermoforming, according to the CMR report. The overall drop in polypropylene demand from swapping to HDPE, PS and PET could total 12% the report said.

A US-based polymer and resin distributor said polyethylene certainly could see an uptick in demand from higher polypropylene prices. Polystyrene, though, was unlikely to be impacted.

"I'm really not expecting polystyrene demand to increase," the distributor said. "But polypropylene certainly can expect to lose out to polyethylene. There is some talk that polystyrene could be a more stable-priced product, have a more constant price. But I think that might have been overstated."

The more likely scenario, he said, was that stronger propylene and polypropylene prices would result in more on-demand propylene production in the US.

"We've already heard of some announcements," he said. "Dow has announced. But announcing doesn't mean doing. We can believe those projects are happening when they start moving the dirt."

Dow said it will construct a propylene dehydrogenation plant in the US at its Freeport, Texas site. It is scheduled to start production in 2015. The company also is considering a second propylene plant to start up in 2018. The Dow capacity is expected to be for internal use, not for the spot market.

"PDH economics are very profitable right now," the resin distributor said. "If you're using a new technology, there is money to be made producing through PDH."

The news of Dow's PDH plant plan was followed by the company signing a definitive agreement to sell its global polypropylene business to Braskem for \$340 million. The divestiture of the polypropylene business was consistent with Dow's long-term strategic business model, chairman and CEO Andrew Liveris said.

"We are dampening volatility and putting our propylene into high-value end uses," Liveris said. "You can assume that by doing this deal, we are liberating ourselves to do that."

"We are taking what we make into our value-add, high-end uses like acrylics and epichlorohydrin and propylene oxide."

At the time of the sale, Liveries appeared to confirm that Dow was committed to building the second PDH unit, saying: "This adds to the closure that when we are done with our second PDH unit, we will be 100% captive."

Braskem is expected to negotiate a contract to buy its feedstock propylene from Petrologistics, which currently provides feedstock to the Dow polypropylene business.

POLYPROPYLENE EXPORTS IMPACTED

Higher propylene and polypropylene prices in the US will also impact trade flows, the resin distributor said.

"In North America – and remember, this is a North American issue, not global – polypropylene [production rates] will be hurt by this," he said. "And the US material is going to have to compete with the Middle East, Europe, Asia."

According to CMR, about 15% of polypropylene production is for export. And as export prices climb, production of polypropylene for export will drop.

"Polypropylene exports (approximately 1 million mt/year) will decrease dramatically due to the high cost of propylene," according to the CMR report. "This will tighten global supply and raise Asian export prices."

Another option to offset the cut in propylene production would be converting methane to propylene using the MTP process – though that option seems unlikely, according to Bauman.

"Lurgi is doing MTP in Trinidad," Bauman said. "It makes sense there. I don't think it makes sense in the US. There is a lot of water involved, creating a lot of garbage water."

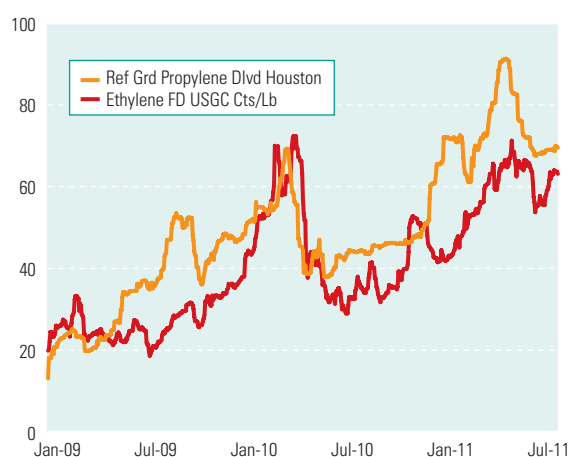
The MTP process would make more sense in regions with less stringent environmental regulations, Bauman suggested, specifically citing China, the Middle East and Latin America.

Jerry Oliver, vice president of sales and business development for Air Liquide – which owns Lurgi – said MTP technology is feasible and being considered in North America.

The company already has constructed four gas-based methanol plants globally, including one in Malaysia, as well as the one in Trinidad. The capacity of those plants – about 5,000 mt/day is enough to feed a 500,000 mt/year MTP unit.

The company has two coal-based MTP plants in China. One is mechanically complete but still being commissioned. The other is

3) US Ethylene/Propylene prices



Source: Platts

operational, though not at full capacity because the coal gasification does not provide enough feedstock to run at 100% capacity.

Gas-based production of methanol, which would be used to feed the MTP process, does produce significant amounts of water – estimated to be between 900,000 and a million mt annually. However, Oliver stressed that the water should not be considered "garbage water."

"We're not talking about black water, or even grey water," Oliver said.

The feasibility of using MTP in the US or Canada will depend on feedstock advantages, not the generation of water, Oliver said. With natural gas priced between \$4 and \$5/MMBtu, MTP would provide a significant feedstock advantage, Oliver said.

"How long are we going to stay [at that price]?, Oliver asked. "As long as you have the advantage, and can sustain that for three to four years, these projects can work."

"No one will build [based] on the market price of methanol," said Ingo Litzenberger, from Air Liquide. "It's too volatile. The value chain has to be gas up to propylene."

PDH is linked to a crude oil feedstock price. Crude oil will in turn drive the price of propylene.

"Propylene prices appear to be tied to the crude, since the classical production technologies (FCC, naphtha crackers and PDH) are fed by crude based/crude related feedstocks." Litzenberger said. "With regard to the PDH, which lives from the spread between propane and propylene, the feedstock cost [propane] are about 80% of the production cost, whereby for MTP the feedstock costs [natural gas] are only about 25%. Consequently, MTP is favored by high crude price scenarios, whereby PDH is favored by low crude prices."

SHALE MIGHT NOT BE A WINNER FOR POLYETHYLENE

While butadiene and propylene could experience tightness because of the shift to lighter feedstocks, the abundance of ethylene and

polyethylene may become as problematic for olefins producers, consultant Bauman said.

While natural gas prices have decoupled from crude oil prices, which makes the shale gas plays attractive as a low-cost energy source, ethane prices also have been decoupling from natural gas (see chart 4). That decoupling is expected to shrink margins for US ethylene and polyethylene producers seeking a cost advantage from shale.

"I certainly wouldn't want to be in the polyethylene business in the US in 2016," Bauman said. "Prices are going to be low. Margins are going to be tight. High-priced production will have to be cut."

There also could be competition from other regions as the shale gas revolution spreads globally.

"The last time there was something similar [in scale] was the very first oil crisis, in the 1970s. That was a turning point. The Middle East finally realized what they had – and they realized they didn't need to be selling (oil) for \$4 a barrel."

At that time, oil companies started to flock to the Middle East, just to ensure oil supply, Bauman said.

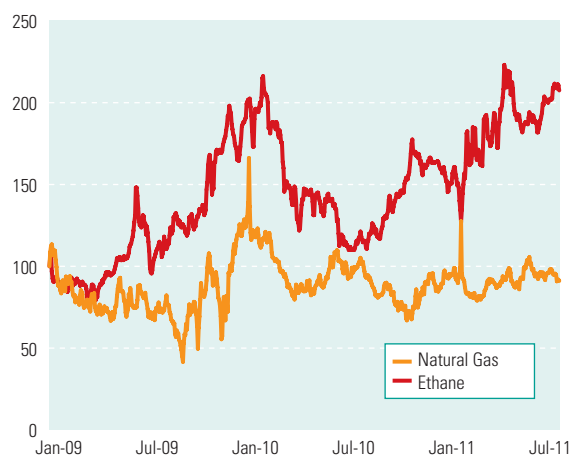
"Mobil placed a PE plant in the Middle East – just as a courtesy to the Saudi government – so they could be guaranteed they had access to oil. At the time, it was Mobil's most valuable property."

The step-change US petrochemical companies face because of shale gas could be as big as those seen in the energy industry in the 1970s, he said.

"(Shale gas) may be as big, once it matures. People here are only focusing on the US. There is also shale gas in North Africa, Eastern Europe, Latin America. The US is going to be the source of technology for those plays."

A new cracker could be built in Poland to feed ethylene and polyethylene into Europe, Bauman said. That would result in higher-

4) US ethane decouples from natural gas



Each product's price has been normalized to 100 as of January 1, 2009 to better illustrate the relationships between the products. The prices do not represent the actual dollar value.

Source: Platts

priced facilities in Europe being shut down. There already was a threat to the higher-priced European polyethylene production from lower-cost Middle East supplies.

The higher-priced production units will likely start to shut down between 2017 and 2020, Bauman said. "That's when we expect to see the real international impact."

As more countries explore for shale gas – and find the same benefits and concerns currently being experienced in the US – the need for on-purpose butadiene and propylene are expected to increase, TPC's Bloesch said.

The result of the global shale gas plays would be "net less butadiene and propylene," he said, resulting in a "strengthening of on-purpose butadiene [and propylene production]."

"A number of major companies in the US [are] making investments in shale gas," Bloesch said. "They see a positive long-term outlook"



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