Rising Tides Lift PAO's Boat

By Boris Kamchev

Chevron Phillips may add to Cedar Bayou.

Chemtura's site in the Netherlands

ExxonMobil's new PAO unit in Baytown

Historically, the 20th century's final decade was a boon for polyalphaolefins, a promising time for the synthetic base stock known as API Group IV. Demand for low-viscosity PAO was healthy, says an industry expert, and grew an average 5.5 percent a year from 1994 to 2000.

Up until then, Group I mineral base oils had dominated engine oil and other lubricant formulations, and PAO occupied the premium niche. "There was a little bit of Group II and Group III," Sandy Raid-Peters told ACI's European Base Oils & Lubricants Summit in September. Then in 1996 large volumes of Group II came on the market, "and at the end of the century the first Group III capacities were coming on stream."

That's when PAO hit a major snag, he said, recounting the well-known story: "In 1997 Castrol reformulated one of their engine oils that had been made with a PAO/ester-type formulation, replacing the PAO and ester with Group III base oil," related Reid-Peters, ExxonMobil Chemical's marketing technical support engineer in Fawley, U.K.

Rivals oil marketers (including Mobil 1) protested the switch and argued that it shouldn't be labeled synthetic. "By the end of the 1990s, after much discussion, the National Advertising Division [of the U.S. Council of Better Business Bureaus] decided that it was truthful to call Group III base oils synthetic," Reid-Peters went on.

The ruling was not good for PAO. Manufacturers of top-tier engine oils drifted away from PAO to use Group III base oils in their products. "From that moment on, the ratio of Group III base oil capacity versus low-viscosity PAOs increased dramatically. It doubled by 2000, was five-fold by 2005, and 11-fold by 2012," he said.

Despite these circumstances, "PAO demand has seen modest but continued growth. Even today the question lingers: What is synthetic — is it Group III, Group IV or Group V?" Reid-Peters noted.

Time moves on though, and new challenges narrowed the lubricant formulating window; these include the ILSAC GF-5, ACEA 2012 and General Motors Dexos1 specifications, and lighter viscosity grades such as SAE 5W-20 and 0W-20. Today's oils impose tough demands for energy savings, low-temperature fluidity and reduced volatility, giving PAO an edge, Reid-Peters showed. Formulators also learned to boost performance by using optimized treat rates of PAO, earning it a new spot in their toolkits. "Engine oils are still thirsty for PAO," he declared.

"Significant impact came from the economic crisis in 2008, when smaller, fuel-efficient cars were much more in demand not because of lower emissions but of the cheaper ride in light of growing gasoline prices," Reid-Peters said at the ACI meeting, which was held in Alicante, Spain.

Modern cars run on smaller but more powerful engines; they work harder, run hotter and crank out more horsepower per cubic centimeter of displacement. The upshot: "Less oil in the engine is doing more work under higher temperatures and higher bearing pressure. All that puts great stress on the oil."

ExxonMobil's latest forecast sees energy demand for transportation rising 40 percent by 2040. "Most of this growth is coming from the heavy-duty vehicle sector, which will grow by 70 percent," Reid-Peters said. "A lot of that growth is going to be in the Asia-Pacific region."

Over the same period the world's fleet of passenger cars is expected to

Vehicles and industry both propel demand

"Low-vis operating rates are fairly elevated, and are expected to be above 95 percent — if feedstock supplies are adequate."

double, he added, "but the move to more improved lubricants and better technology means that the fuel economy targets, in a bounce effect, will also double, with larger efficiency gains." The gains may offset the volume demand for transportation fuel and lubricants — but they also will ratchet up the performance demands.

Lubricant designers will respond in many ways: by moving to lower viscosity oil (which cuts churning losses and improves low-temperature pumpability); by reducing friction; by using advanced additive systems with friction modifiers and antiwear chemistries; and finally, through better base oils.

Back in the 1970s and '80s, engine oil drain intervals were typically 3,000 to 10,000 kilometers; today they can be triple that. "The challenges for the industry are how to maintain lubricant service performance, stability for extended drain intervals, wear protection and durability," Reid-Peters contended.

ExxonMobil Chemical expects low-viscosity PAOs to grow 3 percent to 4 percent annually in the coming years. "It could be higher but that will depend on specifications, and what sort of viscosity grades the different original equipment manufacturers decide to go for in the future," he said.

The high-viscosity PAO market is also booming, which prompted the company last year to open a new plant in Baytown, Texas, with 50,000 metric tons of high-vis PAO capacity. ExxonMobil Chemical's PAOs are sold under the SpectraSyn banner, and also made in Beaumont, Texas, and Gravenchon, France.

Will global PAO supply keep up as demand grows? Miles Oberton, global PAO manager at Chevron Phillips Chemical, pondered that question at December's ICIS Pan American Base Oils & Lubricants Conference in New Jersey. Chevron Phillips Chemical, he pointed out, has captive supplies of the olefins used to make PAO, and is bringing more of these feedstocks on line in 2015. That includes decene (C_{10}) and dodecene (C_{12}) used to make its low-vis PAO, and octene (C_8) that underpins its high-viscosity PAOs. All its PAOs are sold under the Synfluid brand.

"We now have a 10,000-ton-per-year expansion study under way at Cedar Bayou, Texas, which would start up in 2016 and take us to 58,000 tons of PAO capacity there," Oberton said. Although final approval still must come from Chevron Phillips' top echelon, "we made the proposal and announced it now to show our commitment to the industry." Next the company plans to build a massive new ethylene cracker on the U.S. Gulf Coast by 2017, and already has environmental permits in hand for it. This would cement its feedstock capabilities.

Oberton also highlighted areas where PAO outperforms Group III base stocks, such as its friction coefficient. "A 4 centiStoke PAO has about 22 percent better friction reduction versus API Group II and III stocks of the same grade," he stated. Its low-temperature viscometrics and lower volatility are other strengths, plus PAO has the oxidative stability needed for longer-life lubes.

"Its lower volatility means PAO will be used to balance other base stock properties, and meet specifications," Oberton continued. Another key benefit is PAO's specific heat and thermal conductivity. A PAO based lubricant removes 10 to 15 percent more heat than mineral oils of the same weight, and allows equipment to operate at higher temperatures. For end users, that translates directly into energy savings.

Currently, the world has just three suppliers of low-viscosity PAO — ExxonMobil, Chevron Phillips and Ineos — and each operates plants in both North America and Europe. Two others (Chemtura and Naco) make high-vis PAO but the global fraternity remains limited "mainly due to technology constraints and access to feedstock," Oberton noted.

"We anticipate that the low-vis PAO demand will

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PAO's Global Footprint

Company	Location	Capacity (t/y)	Type
CP Chem	Cedar Bayou, Texas	48,000	low-vis
CP Chem	Pasadena, Texas	9,000	high-vis
CP Chem	Beringen, Belgium	63,000	low-vis
Chemtura	Elmira, Ont., Canada	16,000	high-vis
Chemtura	Ankerweg, Netherlands	15,000	high-vis
ExxonMobil Chem.	Gravenchon, France	60,000	low-vis
ExxonMobil Chem.	Beaumont, Texas	85,000	low-vis
ExxonMobil Chem.	Baytown, Texas	50,000	both
Ineos Oligomers	Feluy, Belgium	120,000	low-vis
Ineos Oligomers	La Porte, Texas	90,000	low-vis
Naco	Shanghai, China	15,000	high-vis

Source: Chevron Phillips Chemical

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grow by 4 to 6 percent in the next year," he said. "Low-vis operating rates are fairly elevated, and are expected to be above 95 percent — if feedstock supplies are adequate." Planned and unplanned downtime at ethylene plants could be a hobbling factor here. "We're seeing fairly high capacity utilization rates now, so with only three big producers competing in low-vis PAO, it's immediately felt when someone shuts down.

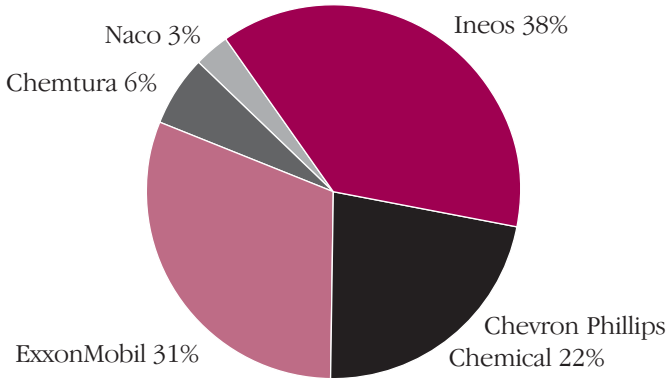
"Limited growth in feedstock has challenged growth in PAO," Oberton added. "But on the high-viscosity side, we expect to see 4 to 7 percent average annual growth from 2013 to 2015 (although that's starting from a smaller base of global supply)." There have been some recent high-vis expansions, including Chemtura in the Netherlands, Naco in China, and most emphatically ExxonMobil Chemical in Baytown, Texas.

Chevron Phillips Chemical estimates that 75 percent of PAO is currently used in transportation lubricants — split roughly two-to-one between consumer and commercial products — and the rest goes into in industrial oils.

For more proof of PAO's wide acceptance, look no further than industrial lubricants, advised Michel Sanchez-Rivas, PAO market development manager at Ineos Oligomers. Based at the company's Feluy plant south of Brussels, he told the Alicante meeting that Ineos is Europe's largest producer of both PAO, which it brands as Durasyn, and its linear alpha olefin feedstock.

Of the PAO base oils used in industrial fluids, 42 percent goes into hydraulic and transmission fluids, Sanchez-Rivas said. Ten percent goes into general machine lubricants, "while the share of soluble and neat metalworking fluids,

Share of Global PAO Capacity



Source: Chevron Phillips Chemical

gear oils, turbine and compressor oils is about 7 percent each." Electrical oils use 4 percent, special engine oils 3 percent, and rust preventives 2 percent. One percent goes into quenching oils, and the rest into non-lubricating fluids.

Using PAOs in industrial applications improves overall efficiency, Ineos has found, giving stability at low and high temperatures. "PAOs decrease operating temperatures in the machines' assemblies and components, they form less foaming tendency and give better wear control. PAOs decrease lubricant consumption and [increase] working hours on equipment. Also, they decrease global maintenance costs and give improved reliability," Sanchez-Rivas declared, going on to give several examples:

- In wind turbines, PAO can be blended with esters and additives to meet the difficult specifications for low-temperature flow and filterability, water tolerance and rust and corrosion performance. PAOs also can achieve Flender foam, bearing corrosion and micropitting test approvals, and are compatible with seals and paints.
- In screw compressors, a PAO based lubricant delivered twice the operating hours versus a conventional turbine oil, before starting to show signs of viscosity increase. In some cases, bearing wear has been reduced by a factor of 10.
- In pumps that switched to PAO based lubricants, drain intervals were extended in 80 percent of cases, often to as long as two years.

"PAOs remain frequently the best choice to formulate industrial lubricants," Sanchez-Rivas asserted. "They offer a good compromise between cost and performance to meet OEM requirements, and also they are available worldwide in reasonable amounts."

In combination with lower-cost unconventional base oils, such as Group II and Group III, Sanchez-Rivas said PAO can match most of the stringent requirements for modern equipment, and offer substantial manpower and maintenance cost savings. "Some newly developed PAOs can also help in biodegradable fluid formulations and gain eco-labels, to decrease the environmental footprint," Sanchez-Rivas noted.

Use of PAOs is more "strategic" now than it was 20 years ago, Chevron Phillips Chemical's Oberton emphasized, with PAO adopted in places where it can deliver demonstrable technical benefits over Group III. For this reason, "we believe there will be room for both," he stated.

"We believe that PAO is a key component not only for today's engine oils, but for the future. And despite the rumors," Reid-Peters concluded, "PAO is not dead." ▮

Lisa Tocci contributed to this article.