BY RAJIV TARIBAGIL

NEXT GENERATION VISCOSITY MODIFIERS

Some of the biggest drivers for change in the heavy-duty diesel vehicle market are improving fuel economy, increasing oil drain intervals and reducing tailpipe emissions. While much has been written about the impacts these demands have on lubricant formulations, little has been said about the impact on the design of next generation viscosity modifiers.

Reducing Fuel Consumption

Fuel economy improvement, the first of the three key drivers for change in the heavy-duty diesel market, is being driven by both government legislation and consumer demand for reduced operating costs worldwide. In North America, for example, beginning in model year 2014, fuel consumption standards will require heavy-duty Class 8 trucks to reduce fuel consumption and greenhouse gas emissions by about 20 percent compared to the 2010 baseline.

The increased focus on fuel economy is reflected in the latest North American API PC-11 heavy-duty diesel engine oil category, which will include PC-11B, a new lower viscosity subcategory, likely to be licensed as API FA-4. Dubbed "fuel economy grades," they are intended to meet the evolving market need for higher fuel economy by introducing lower limits for high-temperature high-shear viscosity at 150 degrees C of 2.9 to 3.2 milliPascal-seconds in SAE XW-30 grades.

At the same time, a few European original equipment manufacturers are working on the development of lower HTHS engine oils to deliver even higher fuel economy. This, in turn, will require the increased use of high-quality base stocks and co-development of hardware and additive technology.

The drive for improved fuel economy makes it increasingly important for next generation viscosity modifiers not only to be compatible with higher-quality base stocks, but also to provide viscometrics that enable blending of lower viscosity grade oils.

Extended Drains

Longer oil drain interval is another feature that end-users increasingly demand from engine oils. Not only does this help reduce operating and maintenance costs, but it also increases up-time, keeping trucks on the road longer. However, extending oil drains cannot come at the expense of engine durability, and oils must retain their viscosity over their lifetime in the engine.

This requires viscosity modifiers, which are major contributors to engine oil viscosity, to have the ability to withstand the high-shear environment of an engine; that is, to demonstrate high shear stability. However, oil viscosity is a delicate balance: Too low or too high and efficiencies will be lost, negating its impact.

Reducing Emissions

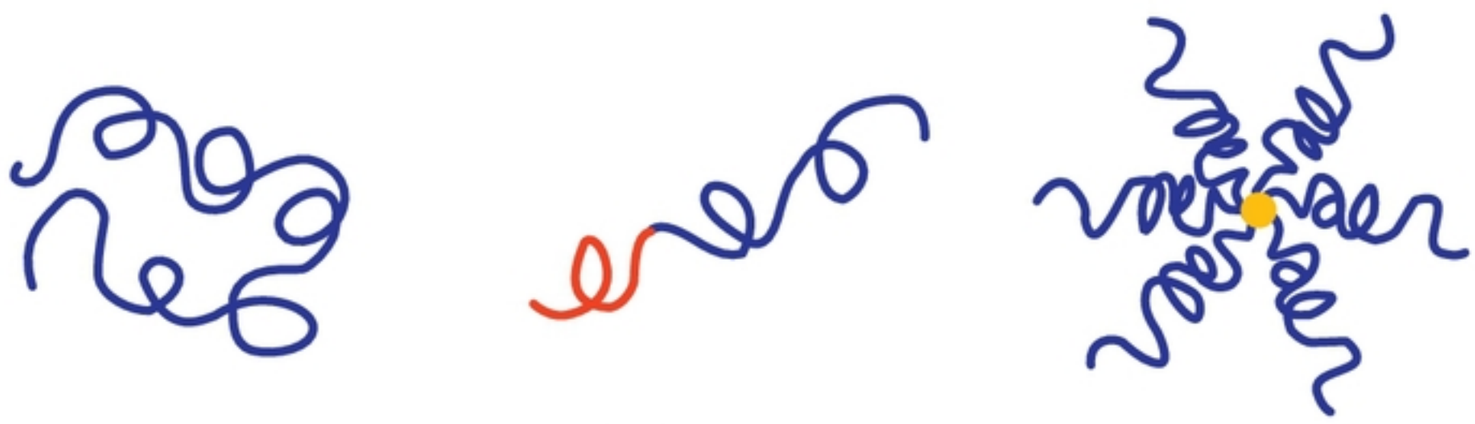
Improving air quality has been a key focus of legislators around the globe, and the reduction of nitrous oxide emissions from truck tailpipes has received significant attention. In the early 2000s, North American heavy-duty diesel engines incorporated exhaust gas recirculation (EGR) technology as an effective strategy to control these emissions. EGR cuts emissions by recirculating cooled exhaust gas back into the engine to lower the temperature of combustion, thus reducing NOx formation in the combustion chamber.

However, EGR led to high soot loading in engine oils under certain operating conditions, causing other issues such as abrasive wear and oil thickening. Newer engines use a combination of EGR and selective catalytic reduction (SCR) aftertreatment, allowing them to operate at low EGR while also limiting soot generation. However, engine builders have expressed the desire for next generation viscosity modifiers to contribute to soot handling and to be backward compatible with older engines.

Next Gen VM

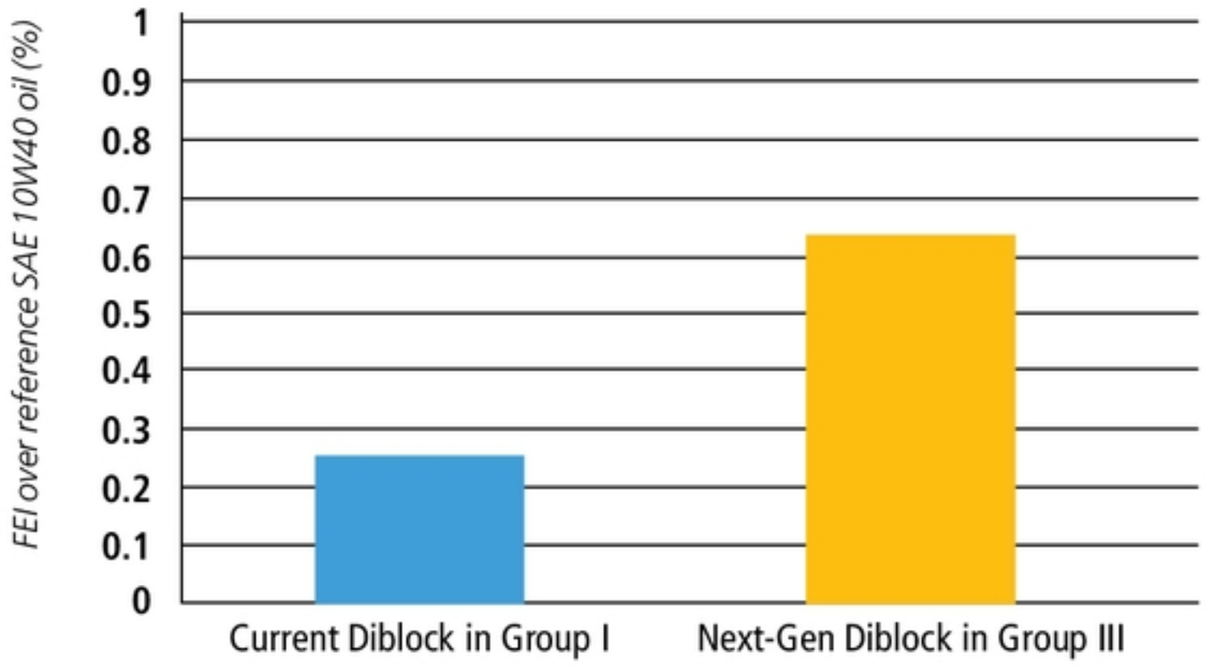
The three key challenges impacting heavy-duty lubricant formulations – improving fuel economy, extending oil drain and reducing emissions – mean future viscosity modifiers need to provide other features in addition to their primary function of thickening engine oils. This requirement led Infineum to explore different polymer

Viscosity Modifier Structures *Source: Infineum*



Linear Polymer | Diblock Polymer | Star Polymer

Fuel Economy Comparison *Source: Infineum*



options to pinpoint the best performing chemistry.

Three different polymers – linear, star and diblock – are commonly used today. In Infineum's experience, the diblock architecture, with its ability to contribute to soot handling, is well-positioned to protect older, current and future heavy-duty diesel engines. This is exemplified in the Mack T-11 soot handling test.

Infineum set out to develop a new diblock to enable the blending of lower viscosity grade engine oils and increase formulation flexibility through the use of better quality base stocks, all while reducing viscosity modifier treat rate. At the same time, the new polymer needed to retain or improve attributes provided by current commercial diblocks, such as shear stability and soot handling.

The next generation diblock polymer comprises a polystyrene block with its molecular weight tuned to enhance compatibility with better quality base stocks (API Group II and higher) and a revised hydrogenated polydiene block to provide good thickening and high shear stability.

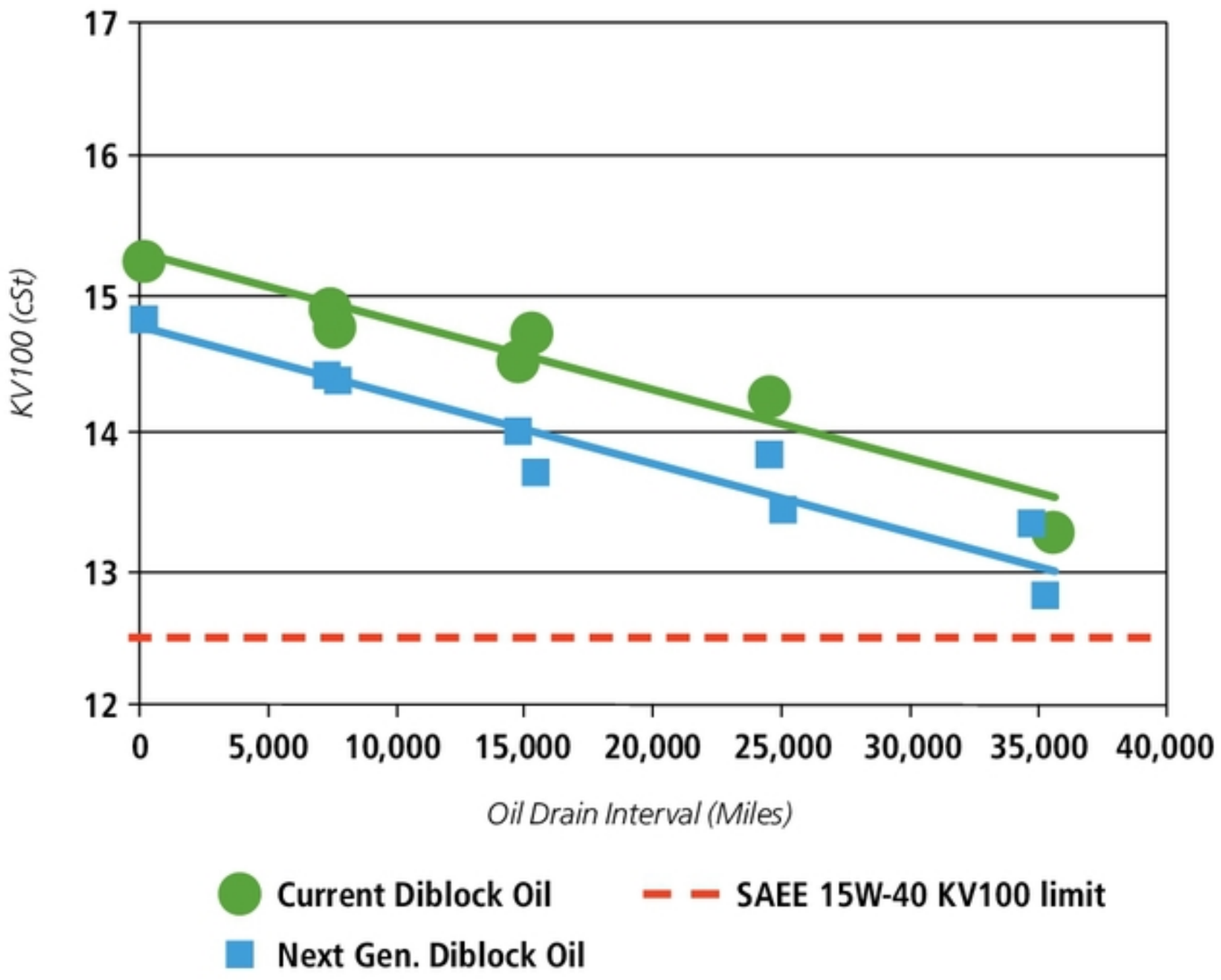
Following the design phase, the second step was to test the diblock in finished oils. Two top-tier SAE 10W-40 oils were formulated. One, acting as a reference, used a currently available commercial diblock in an API Group I diluent oil. The candidate oil used the new diblock in a Group III diluent oil.

The results showed that the next generation diblock allowed increased use of heavier base stocks while still maintaining favorable low-temperature performance. In addition, the new polymer could be treated 15 percent lower compared to the commercially available diblock.

Blending with the new diblock in a Group III diluent oil, an SAE 5W-30 oil with high-temperature high-shear viscosity of 3.0 mPa-s and stay-in-grade kinematic viscosity at 100 degrees C was formulated without the need for correction fluids. In addition, the oil increased fuel economy in an OM 501 LA Euro 5 engine compared to the conventional 3.5 mPa-s HTHS oil blended with a currently available commercial diblock in a Group I diluent oil.

To meet the long drain interval requirement, the next generation diblock needed high shear stability. To demonstrate this attribute, current and next generation diblocks blended in SAE 15W-40 oils were compared. After 90 cycles of shear in the Kurt Orbahn tester, the kinematic viscosity at 100 degrees C of the next generation diblock oil stayed within grade and maintained similar performance to the current diblock oil.

Drain Interval Comparison *Source: Infineum*



From Bench to Real Life

To ensure the bench test results translated to field performance, the durability of the candidate and the reference SAE 15W-40 oils were compared in a field trial in modern high-shear diesel powered trucks. These engines are representative of high-shear environments that heavy-duty diesel engine oils would

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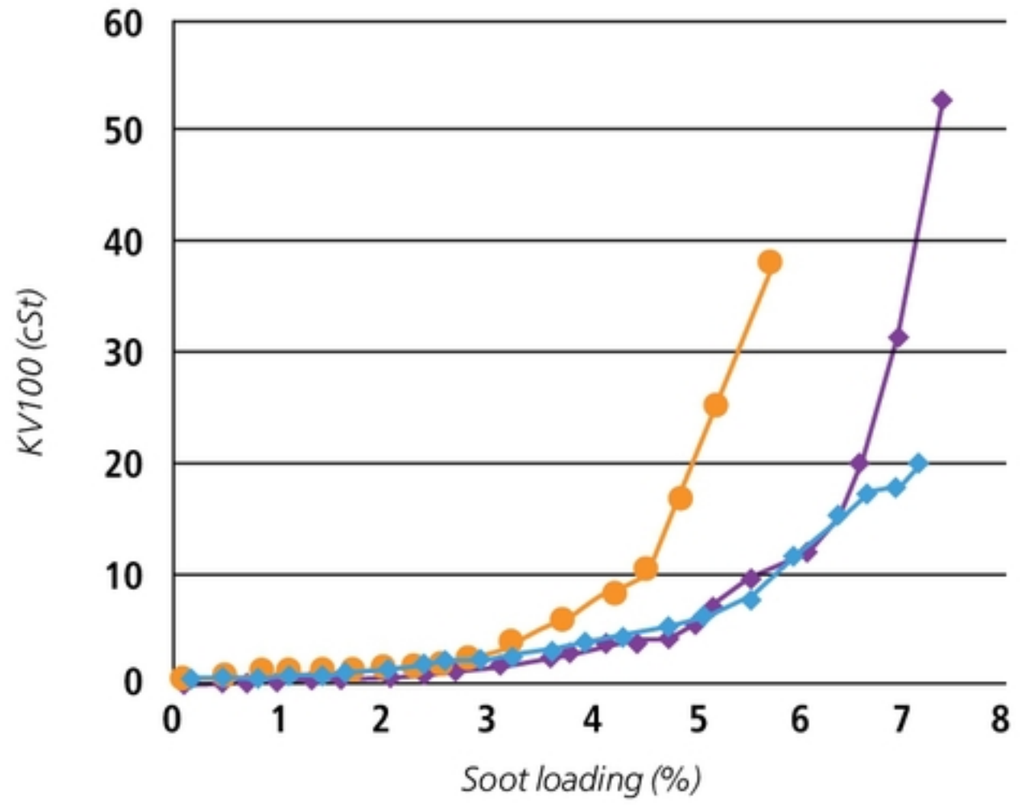
Soot Handling Capability *Source: Infineum*



typically experience in off-highway and on-highway applications.

Although the viscosity data was corrected for fuel dilution, it remained well within grade to an extended drain interval of 35,000 miles (56,327 kilometers). The manufacturer's recommendation for this service was 25,000 miles. Also notable was the low wear metal content at the end of the test, which confirmed the long retention of the oil's lubricating viscosity under the different shear and temperature regimes of the engine.

The new diblock also needed to deliver soot handling capability at least comparable to that provided by current commercial diblocks. An SAE 10W-40 oil was blended to deliver borderline soot handling performance in the Mack T-11 soot handling engine test. When blended with a star polymer viscosity modifier, without the ability to handle soot, oil viscosity rose sharply beyond 4 percent soot content. When substituted with a current commercial diblock, soot-induced viscosity rise was controlled up to 6 percent soot content.

The next generation diblock also was treated 14 percent lower to match viscometrics. The same boost in soot handling was observed, which demonstrates that similar performance at a lower treat rate was delivered. In both bench and field testing, the new diblock polymer provided formulation flexibility, improved thickening efficiency and effective soot handling while also delivering shear stability comparable to that of currently available products. □

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Sany Group is a global company in the construction machinery industry and produces concrete machinery, excavators, hoisting machines, pile drivers, road construction machinery, port machinery and wind turbines. It boasts five industrial parks in China and four R&D and manufacturing bases in America, Germany, India and Brazil.

IPAC Opens in Belgium

International Petroleum Products and Additives Co. Inc. has opened a new production facility in Ghent, Belgium. The plant manufactures a variety of additive packages for use in automotive, heavy duty, industrial and driveline lubricants, as well as fuel additives.

Valvoline Partners with Oiltech

Valvoline has named Oiltech Lubes Service GmbH & Co. KG as sales and logistics business partner for Valvoline's high-performance lubricants and automotive chemicals in Germany, Austria and Switzerland. Oiltech has also been named authorized Tectyl sales and logistics business partner in Austria and Switzerland.

"This is an excellent strategic fit for our organization, and we are excited to have Oiltech as a sales and logistics business partner of our high-performance Valvoline products," said Vladimir Golub, Valvoline regional business manager in Europe. Oiltech was founded in 2001 and has annual lubricant sales of 4,000 tons.

Krahn, Oxea Expand Cooperation

Krahn Chemie has assumed distribution of Oxea specialty esters in France and has established a sales team that will operate from the French branch of sister company Albis Plastic during the initial phase. Krahn plans to expand its presence in France and set up its own subsidiary in the near term.

Oxea and Krahn have been working together in the field of specialty esters in Germany, Austria, Switzerland and Eastern Europe. These products are used as plasticizers in processing plastics and rubber, in adhesives and sealants, as well as in paints and coatings, and as synthetic esters in lubricants.

Agrinol, East Petronics Team Up

Ukrainian lubricant manufacturer Agrinol and East Petronics Ltd. of the United Arab Emirates plan to open blending plants in Georgia and Latvia. The companies, which have been partners since 2012, said the projects are financed by international investors. Each plant is being designed with capacity of about 10,000 tons per year.

"This past fall we broke ground on the Georgia plant … and the [start-up] is expected by June," Julia Govorova, foreign trade department manager at the Agrinol group of companies, said in an interview. "The Latvia site is in the planning phase, and the inauguration date is not determined yet."

The blending plant in Latvia will be located in Liepaja, a Baltic Sea port city. The plant in Georgia is being constructed on the site of a former truck assembly plant in Kutaisi.

Dmitriy Koverniy, head of Agrinol's import department, said in a news release, "The joint project with East Petronics is part of the company's strategy to shift our sales elsewhere." He said that after Russia imposed an embargo on many Ukrainian companies, Agrinol lost a market that consumed a substantial part of its production. "In 2014, we stopped exports to Russia. It amounted to a significant volume of our total production, or 15,000 tons of lubricants annually. It hurt our sales and forced us to change our strategy and turn to the other markets."

Agrinol's partnership with East Petronics began four years ago when the Ukrainian company began toll blending lubricants that East Petronics then marketed. □