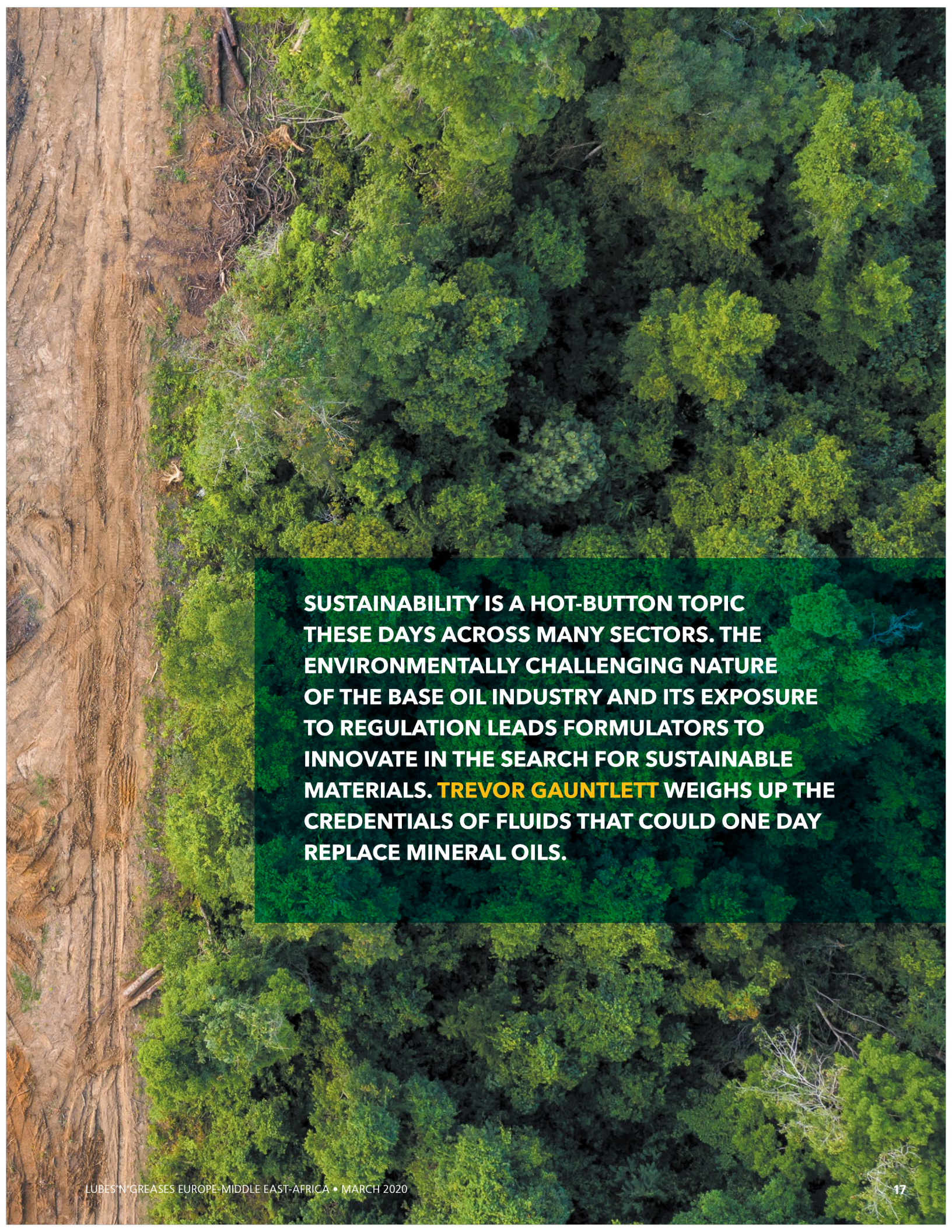


An aerial photograph of a construction site. The ground is heavily marked with the tracks of heavy machinery, creating a complex pattern of lines and curves. In the upper right quadrant, a blue excavator is visible, partially obscured by the tracks. The overall scene is one of intense industrial activity in a rugged, earthy environment.

A NEW WAY FORWARD

An aerial photograph showing a dense green forest on the right and a muddy, rutted road on the left. The road has deep tracks from heavy machinery. The forest is lush and green, with some fallen branches visible. A semi-transparent dark green box is overlaid on the forest, containing white text.

SUSTAINABILITY IS A HOT-BUTTON TOPIC THESE DAYS ACROSS MANY SECTORS. THE ENVIRONMENTALLY CHALLENGING NATURE OF THE BASE OIL INDUSTRY AND ITS EXPOSURE TO REGULATION LEADS FORMULATORS TO INNOVATE IN THE SEARCH FOR SUSTAINABLE MATERIALS. **TREVOR GAUNTLETT WEIGHS UP THE CREDENTIALS OF FLUIDS THAT COULD ONE DAY REPLACE MINERAL OILS.**



ne of the most exciting chemistry developments in the lubricants industry in recent years has been

the commercialization of high-performance base fluids and additives derived from plants. These include new types of molecules and materials that bring genuine performance advantages that had previously only been available from petrochemicals. Meanwhile, new routes to existing molecules have opened up, allowing formulators to develop products with familiar componentry that meet the requirements of several environmental certification programs

“Many fluids may be described as ‘renewable,’ but that’s not necessarily the same as ‘sustainable,’” Germany-based sustainability expert Apu Gosalia told *Lubes’n’Greases* last year. “Sustainability is a term that seems to have a million definitions. In our

industry we should know; not everything that is renewable is necessarily sustainable.”

Gosalia cited examples of palm oil-derived products, which are considered renewable, but if they come from palm plantations that are the result of deforestation, they should not be described as sustainable.

New Molecules

Estolides are one such new molecule. They were featured in *Lubes’n’Greases* EMEA in March 2019 and can be base fluids or additives. Chemically, estolides are esters, so the manufacturing chemistry is relatively simple. They can be made from ricinoleic acid by a simple esterification reaction, whereby the acid group of one fatty acid reacts with the hydroxyl group of another fatty acid. The carbon-carbon double bonds (one per chain) are hydroge-

nated to remove sites of oxidative instability.

Hydrogenation of ricinoleic acid is a common process in the lubricants supply chain, as it produces 12-hydroxystearic acid, the most important natural fatty acid in grease thickener production.

The first commercial sales were made by Biosynthetic Technologies in mid-2019 and now three viscosity grades are available for customers globally. Matt Kriech, chief operating officer at the Indianapolis-based company, explained that they had made significant steps in the past year to take a laboratory product and make it in universally available equipment, such as the types of batch reactors used to make esters. Talking to *Lubes’n’Greases*, Kriech explained, “We are currently toll-blending our BT-branded range in India, where we have ready access to ricinoleic acid from castor oil production.”

Each grade is produced in its own batch, but all grades can be manufactured in the same reactor using the same raw materials.

“Essentially the only difference between batches is the length of time we allow the reaction to proceed before we add the capping molecules,” said Kriech. High oleic soybean oil is another potential feedstock, likely for production in the Americas, where it is readily available.

Biosynthetic Technologies’ Chief Executive Officer Mark Miller was keen to emphasize the high sustainability scores for the company’s products. “We like the Indian producer because it’s a zero carbon footprint facility. They use wind turbines for electricity and the boilers burn waste from the castor mill. We have no transport of our raw materials, as the reactors are co-located with the castor processing plant,” he said.

Biosynthetic Technologies commissioned a lifecycle study into the

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estolides. All stages of the lifecycle were analyzed, from raw material acquisition to manufacture, transportation and applications. Material and energy flows were studied, including the environmental inputs of water, energy and land resources and outputs such as emissions to air, water effluent and waste. They were then examined on the basis of their environmental impacts, including global warming potential, habitat alteration due to castor oil farming, ecological toxicity, water use and emissions.

“Castor has a socio-economic positive. It’s a low-cost crop, so gives the poorest farmers the best chance to generate income. Also, it doesn’t compete with food crops,” Miller said.

Performance

With such glowing sustainability credentials, are estolides any good as lubricants? Estolides retain some of the performance benefits of the esters that have been on the market to date, such as high lubricity and natural detergency. The structure of these molecules also protects them against oxidation and hydrolysis. In addition to their high bio-content (not 100 percent because the capping molecules are often petrochemicals), they have high biodegradability. The products now commercialized by Biosynthetic Technologies have pour points of around minus 20 degrees Celsius and viscosity indices well above those of API Group III base oils.

Biosynthetic Technologies believes customers are using their products in hydraulic oils, greases and some high-performance fluids for environmentally sensitive applications. In addition, the company has formulated SAE 5W-20 and 5W-30 motor oils with a conventional ILSAC GF-5 additive package from one of the major suppliers. The fluids, which contain around 35 percent estolide, achieved

first-time passes in each of the sequence tests for GF-5. The 35 percent estolide content means that the formulation comfortably meets the criteria of the U.S. Department of Agriculture’s BioPreferred Program, a scheme to promote the uptake of biobased products. The commercial robustness of the company’s products is further demonstrated by their qualification by the U.S. Department of Defense for use in non-combat military vehicles following a two-year field trial.

The lighter (4 centistokes at 100 C) product will allow formulators to develop ISO 46 and 68 products for hydraulics and compressors with higher estolide content. It also makes 0W-XX fluids accessible with a high biobased content, and Biosynthetic Technologies is aiming for an ILSAC GF-6 product in the market prior to the end of GF-5 licensing, expected

in 2021. Miller believes that reaching the requirements of GF-6 is more a function of accessing test stands than the capabilities of the estolides to drop-in and replace hydrocarbon base fluids alongside a performance package.

Hydrocarbons from Plants

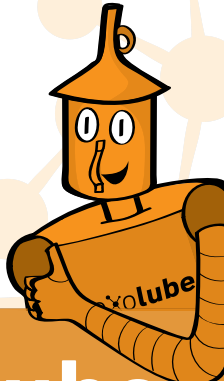
One of the players in this area is Novvi, whose NovaSpec products meet the API’s Group III criteria and are produced from sugarcane cellulose. As they are biodegradable, use of these hydrocarbons in the appropriate amounts allows formulators to produce environmentally acceptable lubricants that meet the specifications for hydraulic environmental polyalphaolefins and related products, according to ASTM D15380. (Novvi did not respond to requests for comments at the time of publication.)



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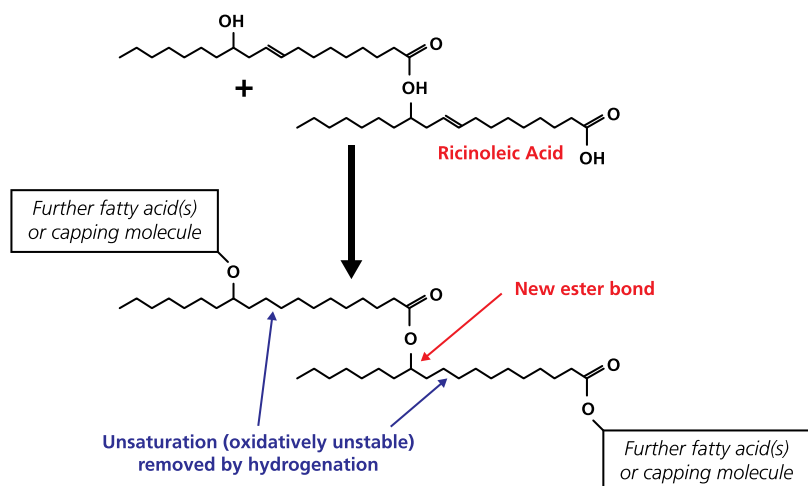


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Estolide Synthesis from Ricinoleic Acid



Source: Lubes'n'Greases

Another company using renewable hydrocarbons in its products is RSC Bio Solutions, a U.S.-based developer and marketer specializing in EALs or fluids meeting the criteria of the U.S. Environmental Protection Agency's Vessel General Permit. While the VGP and the European Union's Ecolabel govern the environmental impact of finished products leaking into the environment, the Ecolabel also requires a minimum percentage of the lubricant to come from a non-petrochemical source.

RSC Bio Solutions recently launched its Futerra range of renewable hydraulic fluids carry the HEPR designation and the Ecolabel, due to their use of renewable hydrocarbons.

According to Larry Beaver, RSC Bio Solutions' vice president of research and development, "a quality, sustainable HEPR base oil and state-of-the-art additives combine to give Futerra hydraulic fluids ... performance equal [to] or better than conventional lubricants and offers extended drain intervals."

Futerra exhibits almost zero foam and superior oxidative and hydrolytic stability compared with mineral oil-based (but still biodegradable) HEPR fluids currently on the market, claims Ian Nielsen, RSC Bio Solu-

tions' strategic account executive.

Sustainable Can Mean High Performance

A fluid's sustainability credentials are not a differentiating criterion for some customers, however, and are instead minimal requirements. During a panel discussion on environmentally friendly, high-performance lubricants at the ACI European Base Oils & Lubricants Summit in Rotterdam in November 2019, it was acknowledged that performance and cost are the customer's differentiators. However, Beaver is bullish that his company's products add enough value that customers will want to buy them.

"The days of compromise, where poor performance and sustainability were inevitably linked, are long behind us. It is now clearly possible to have both performance and environmental responsibility in one lubricant technology. These smart, sustainable lubricants minimize risk by maximizing equipment lifetime and decreasing impact on the environment," he said.

But there is still confusion in the market as to how sustainable these options are. How do we differentiate between the claims of esters and

estolides, naturally sourced or biodegradable componentry and even rerefined base oils? Once we can do that, we must remember that sustainable base fluids are only one part of the overall sustainability criteria of a lubricant.

The UEIL's sustainability initiative draws representation from all parts of Europe's lubricants industry process and value chain. It is working on a framework to define, develop and measure sustainability in and for the lubricants industry.

"There are many base fluids for which some 'environmentally friendly' claim has been made," said Gosalia. "The task is to find consistent criteria against which the sustainability of all components and processes can be measured. This will allow customers to make comparisons that help them meet their own or their customers' sustainability goals."

Gosalia does not expect this journey to be quick, but as he noted, "if the lubricants industry in Europe doesn't come up with its own rules for measuring and improving sustainability, the European Union will eventually notice and impose their own rules."

That prospect should be enough to incentivize the lubricants industry in Europe to move tout suite. □

Trevor Gauntlett has more than 25 years' experience in blue chip chemicals and oil companies, including 18 years as the technical expert on Shell's Lubricants Additives procurement team. He can be contacted at trevor@gauntlettconsulting.co.uk

