Bio-Lubricants

Base Stocks and Components for Electric Vehicle Oils and Thermal Fluids

Engineered for Performance, Sustainable by Nature™

Emery Oleochemicals

Driving Innovation for Sustainable Lubricants

Engineered for Performance, Sustainable by Nature™

Founded in 1840, Emery Oleochemicals has a rich heritage developing and manufacturing natural-based chemicals made predominantly from renewable oils and fats. Emery Oleochemicals' philosophy of 'Creating Value' for our customers is evident through our wide-ranging product portfolio that caters to the diverse and unique needs of an evolving marketplace.

Today, over 180 years later, Emery Oleochemicals is known for world-leading, in-depth technical expertise and the production of high-quality specialty chemicals. Through our global operations, we provide our customers with best-in-class sustainable solutions, engineered for performance.

Creating Value, Globally

With Emery's global footprint of technical and commercial contacts in the Americas, Europe and Asia, our Bio-Lubricants business offers strength in product development, manufacturing, distribution, sales and technical support to our customers around the world.

Engineered Solutions for EV

In addition to our existing portfolio of products for EV fluids, our Bio-Lubricants business is open to join technical development cooperation to tackle ongoing challenges for new fluids and lubricants.

Contact us at EV@emeryoleo.com for more technical and application information and to request a TDS or sample of our commercial products.

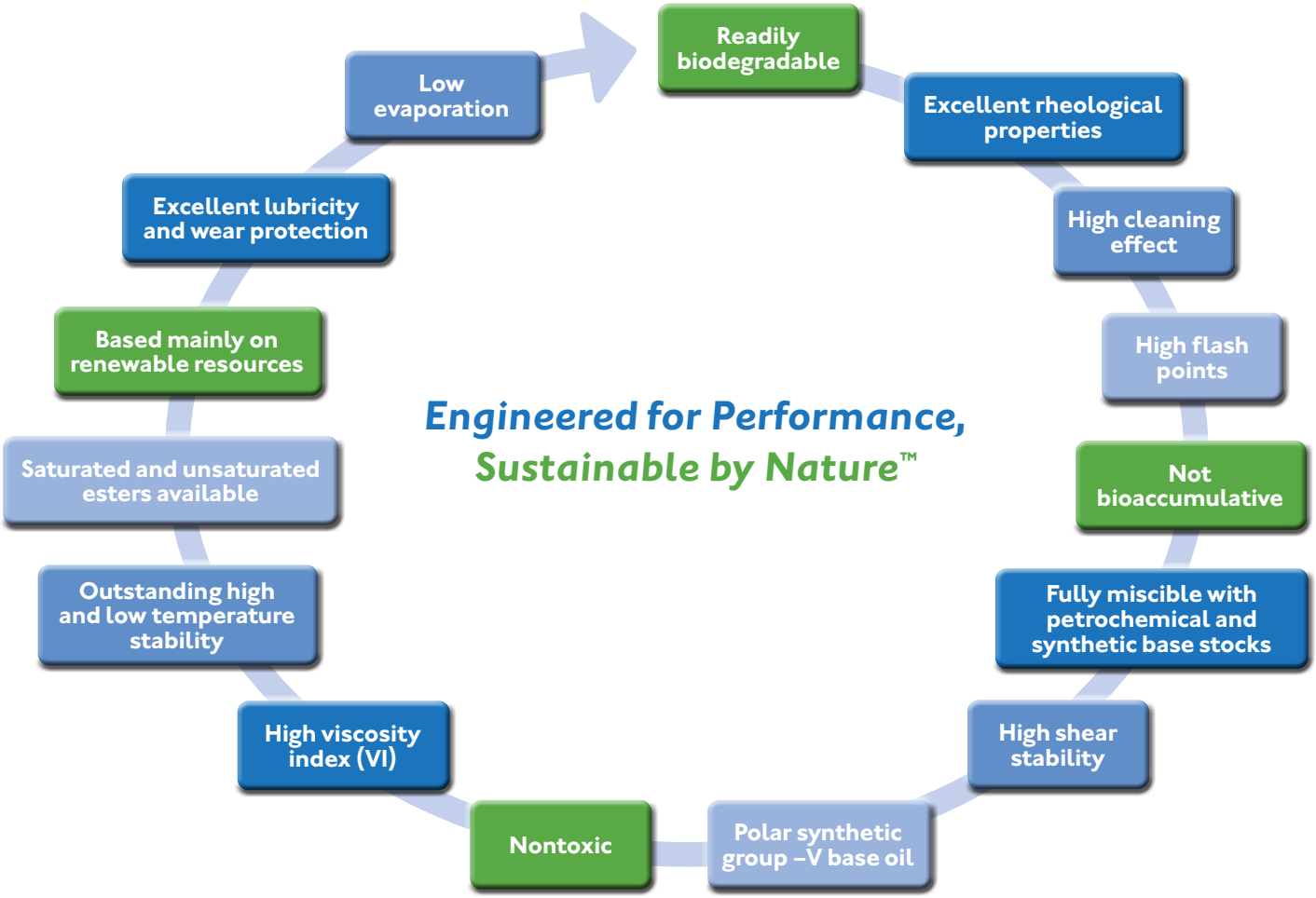
For more information about our portfolio for Electric Vehicles, visit:
www.emeryoleo.com/bio-lubricants/electric-vehicles

CONTENT

Technology & Sustainability Advantages

New fluids for electric vehicles have to fulfill different functionality requirements than currently used lubricants. In particular, good thermal management in combination with the ability to work under the impact of high voltage is essential. Known performance requirements to provide friction reduction and wear protection remain while operation conditions are changing as well. Higher rotational speeds in the electric motor as well as higher loads on the bearing introduce new challenges to the formulating industry.

These new fluids will have to address the arising electrical, thermal, tribological and chemical challenges as well as material compatibilities with the new electric and hybrid engines. Providing necessary lubrication, wear and corrosion protection, high thermo-oxidative stability and long usage are all key to successful development of future dielectric fluids.



Emery's Bio-Lubricants division has responded to this technology challenge and EV market's level of ambition by developing and commercializing high-performance esters for use in new electric vehicle oil and fluid formulations.

DEHYLUB® EV Portfolio

As one of the leading suppliers of environmentally-acceptable base stocks and components, Emery Oleochemicals offers the range of DEHYLUB® ester products to meet the demanding challenges for a variety of electric vehicle applications.

Our ester components can be used for the formulation of finished EV fluids including thermal fluids, transmission oils, and motor oils.

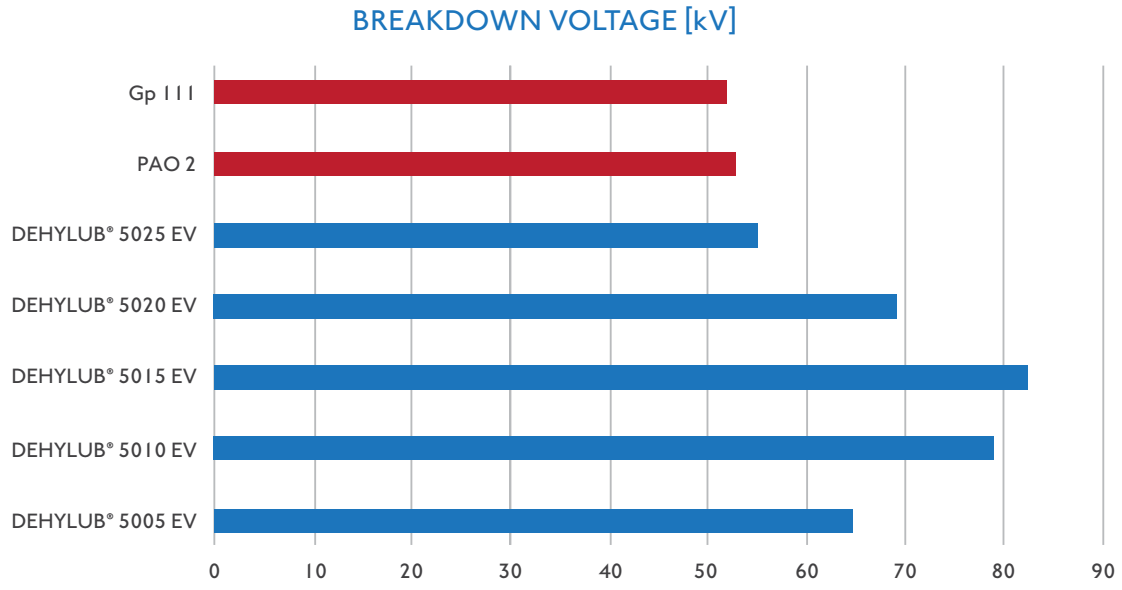
Advantages

- Superior lubricity and oxidative stability
- Excellent low temperature performance and high flash points
- Outstanding cooling and thermal capacity
- High breakdown voltage
- Extended miscibility with most other base stock technologies
- Readily biodegradable

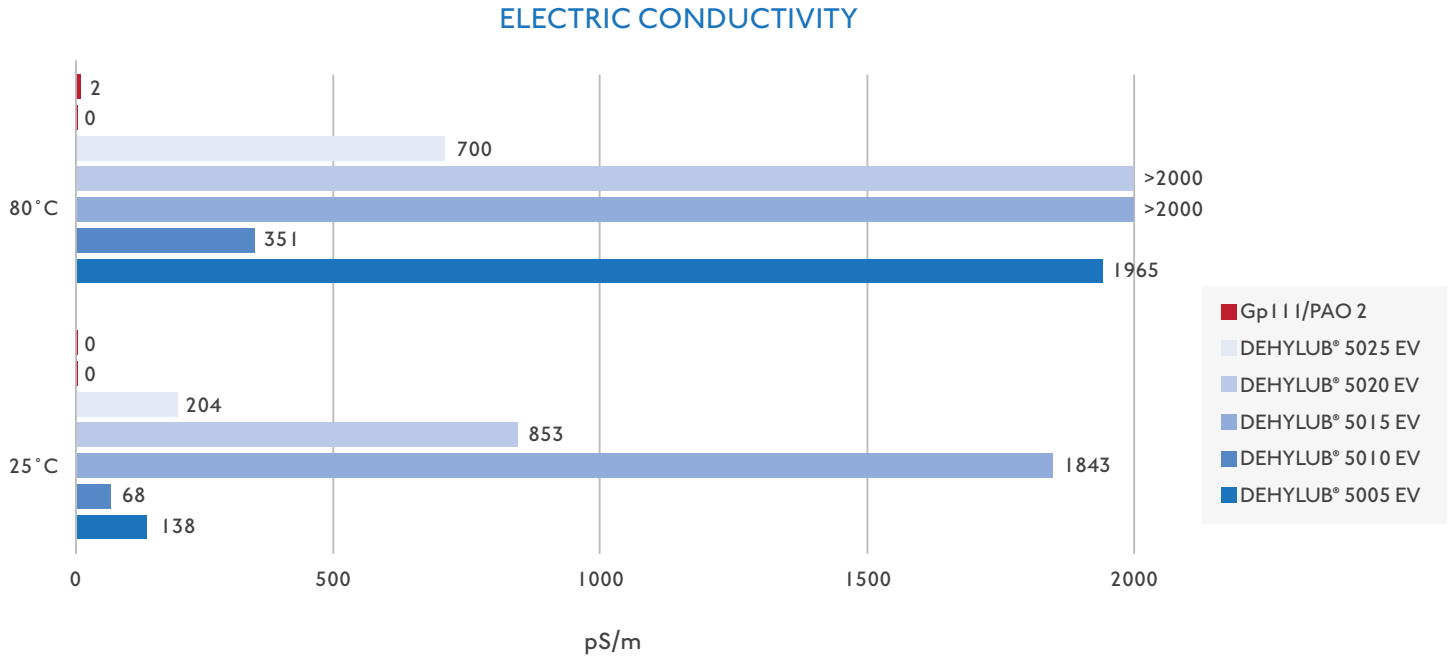
PRODUCT	ACID VALUE	KIN. VISCOSITY AT 40 °C [mm²/s]	KIN. VISCOSITY AT 100 °C [mm²/s]	REFRACTIVE INDEX	POUR POINT [°C]	FLASH POINT [°C]
DEHYLUB® 5005 EV	≤ 0.3	4.5 – 5.5	1 – 2	1.442 – 1.444	≤ -30	> 170
DEHYLUB® 5010 EV	≤ 0.1	26 – 28	5 – 6.5	1.457 – 1.458	≤ -50	> 210
DEHYLUB® 5015 EV	≤ 0.3	10 – 11.5	2.5 – 3.5	1.445 – 1.451	≤ -55	> 200
DEHYLUB® 5020 EV	≤ 0.15	12.5 – 14.5	3 – 4	1.451 – 1.456	≤ -55	> 210
DEHYLUB® 5025 EV	≤ 0.1	10 – 13	3 – 4	1.449 – 1.452	≤ -65	> 210

Dielectric Properties

Ester products exhibit comparable or higher breakdown voltages than petrochemical alternatives. PAO 2 and a Gp III base stock are used as references in this overview. This property indicates the ability of a fluid to withstand higher voltages before discharges and arching will occur.



The conductivity of fluids used in an electric vehicle needs to be considered in the formulation because of their exposure to electric fields and higher currents. Due to their polarity, esters have higher conductivity than the comparable petrochemical base stocks which are nonpolar. When esters with high conductivity are blended with PAOs for example, the desired fluid conductivity level can be achieved by adding the appropriate amount of ester.

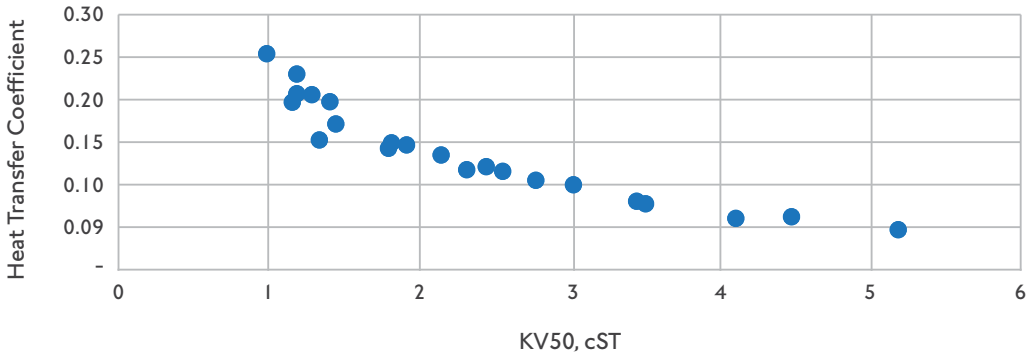


Thermal Management

Thermal management is one of the key performance factors for new fluids to be designed and developed for electric vehicles. This feature is necessary for all new types of fluids like thermal fluids, transmission and engine oils. The ability of excellent control of the operating temperature will increase the battery lifetime, optimize charging time, protect the equipment and lead to longer fluid lifetime.

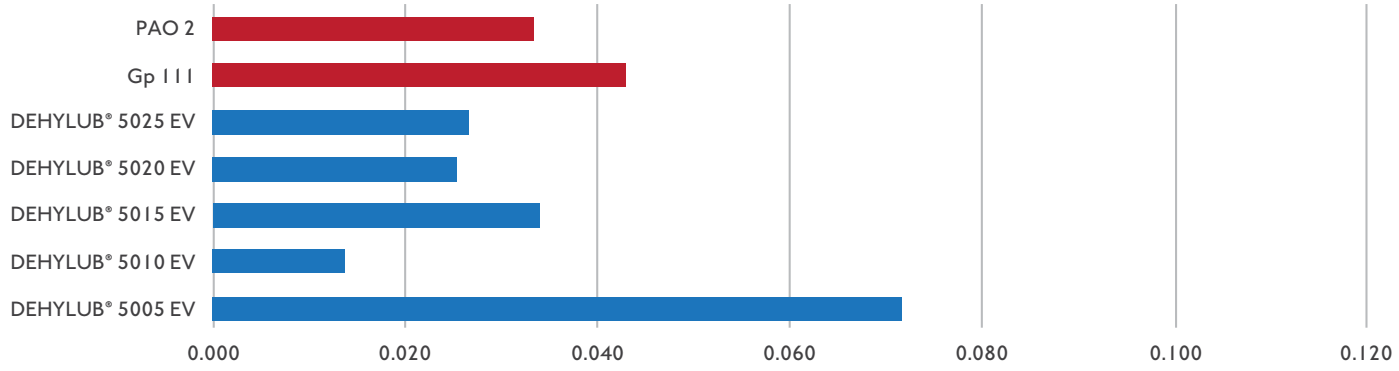
When comparing petrochemical base stocks with ester products, similar or more advantageous performance levels can be observed looking at the cooling capabilities of ester products. As a measure, the heat transfer coefficient can be calculated leading to temperature dependent values and is based on various properties including thermal conductivity and specific heat capacity.

VISCOSITY VS. HEAT TRANSFER COEFFICIENT



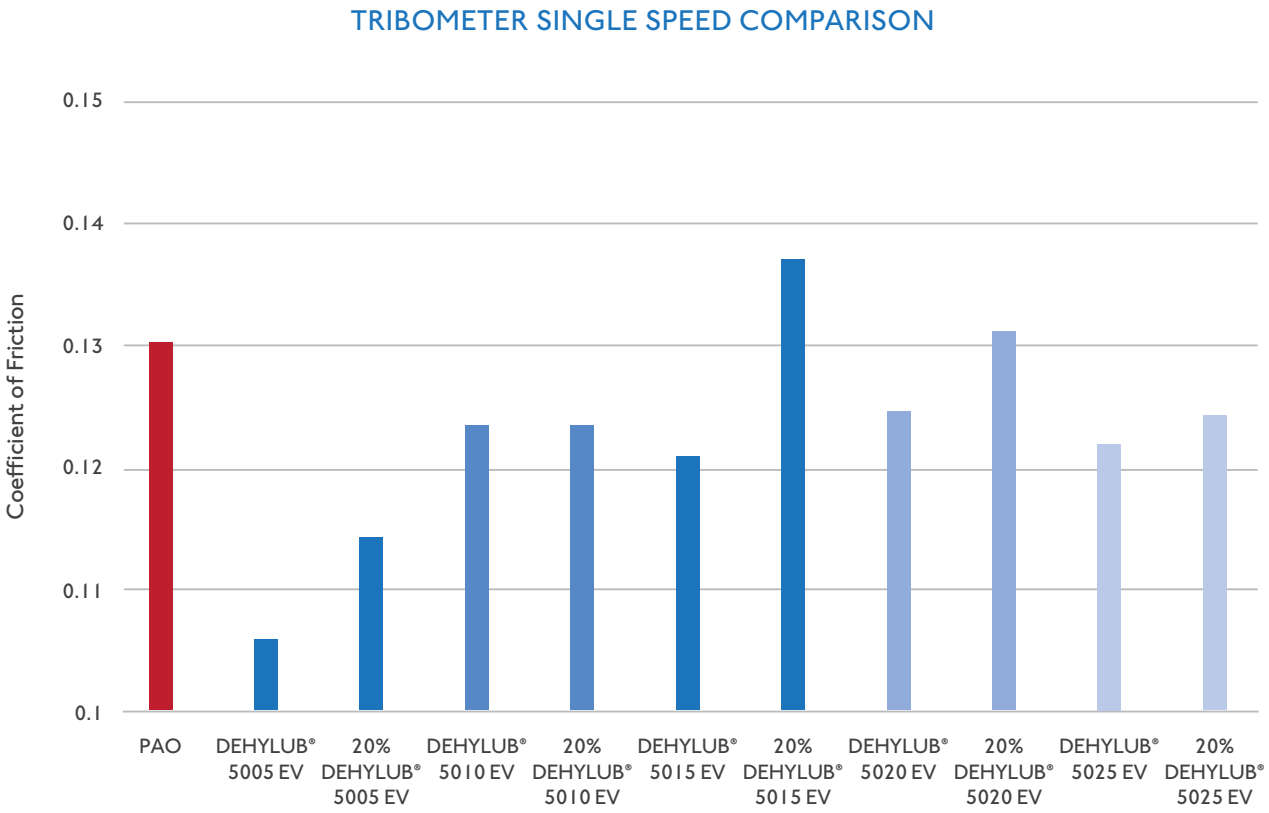
Lower coefficients indicate better heat transfer and cooling capabilities. Data shows that the viscosity profile has the highest impact on the heat transfer coefficient and consequently, the cooling performance.

HEAT TRANSFER COEFFICIENT @50°C



Tribological Performance

Especially in the transmission of electric vehicles, the fluid used will need to perform traditional lubricant tasks by providing friction reduction and wear protection. Since electric motors are running at higher rotational speeds, the bearings must be protected under these challenging conditions which requires lubricant film stability and protection. The combination of these benefits will lead to longer equipment life, lower maintenance, and improved energy efficiency.

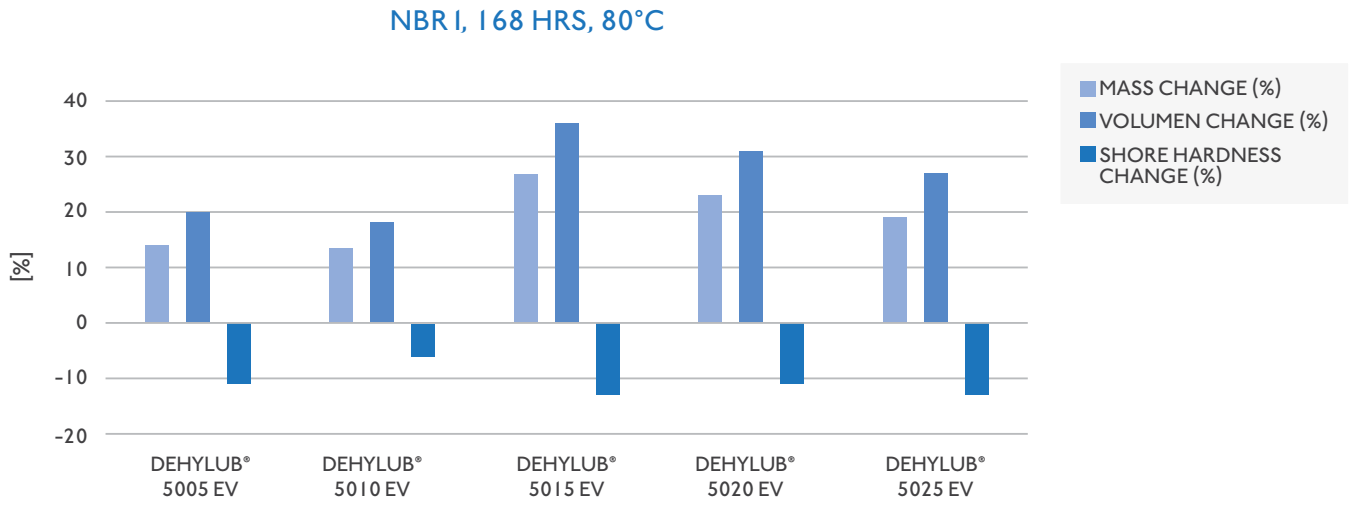


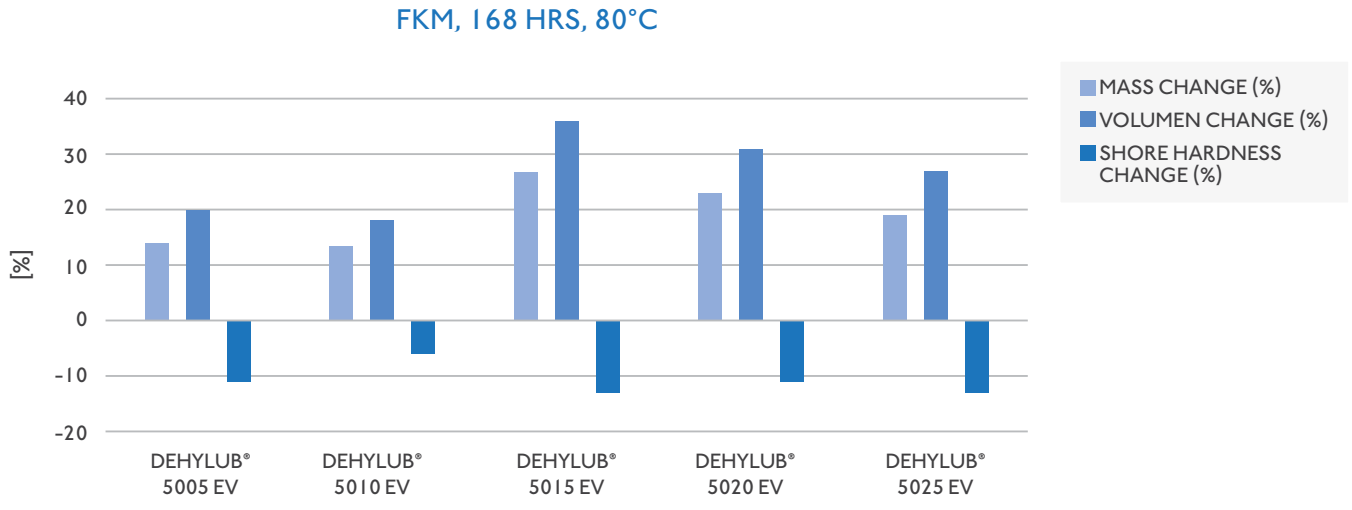
Comparing the performance on the various esters based on the coefficient of friction, most ester products demonstrated lower friction compared to the PAO 2 reference. When looking at blends in the PAO reference, some ester retain the same friction reduction even at a 20% blending ratio. The data table shows the comparison at a single speed under constant load.

Material Compatibility

EV applications not only include known materials, such as metals (steel, copper) and seals, but will also integrate new componentry to meet market demands. Therefore, material compatibility will become even more important in the future.

The data below shows the compatibility of our DEHYLUB® EV product range for the commonly used seal materials NBR I and FKM after a test duration of one week at 80°C.





Exclusive & Custom Joint Development

In addition to our commercial product portfolio for electric vehicles, Emery Oleochemicals is also committed to working with our customers to develop and commercialize innovative and market-leading components for all types of lubricant applications to meet your specific requirements.

Your Preferred R&D Partner

Emery's Bio-Lubricants business can provide the necessary technical expertise and R&D capabilities by engineering products for existing and emerging industry requirements, creating solutions that make an impactful difference.

Our Technical Development Center of Excellence in the US provides ester synthesis and testing capabilities. In addition, pilot synthesis is available.

Our Bio-Lubricants business has a dedicated product and application development lab close to our office in Duesseldorf, Germany. Here, our highly experienced team performs ester design, synthesis, and application testing.

Global Manufacturing

As a global provider of renewable-based, high-performance and innovative solutions for industrial lubricant applications, Emery Oleochemicals provides a unique and comprehensive portfolio for a wide variety of industries, available worldwide from our global manufacturing facilities.

Located on 35 acres in Cincinnati, Ohio, USA, our North American manufacturing facility is home to many pioneering oleochemical technologies that make Emery the largest oleochemicals manufacturer in the Americas and the largest global producer of azelaic acid. This site is RSPO certified to manufacture products in accordance with mass balanced (MB) requirements.

In addition, our purpose-built Specialty Esters plant, dedicated reactors and backward integration into various raw materials ensure security of supply.

Located in Loxstedt, Germany, our European manufacturing plant spans 32 acres and has been operational since 1902.

Our dedicated Esterification plant can produce the entire range of Emery's esters in both liquid and solid form. This site is also RSPO certified to manufacture esters in accordance with mass balance (MB) requirements.

CREATING VALUE FOR OUR CUSTOMERS, ANYWHERE IN THE WORLD.

Global Network

Emery Oleochemicals' operations are supported by a global workforce and an extensive distribution network covering over 50 countries worldwide. Our technical and industry experts located around the world are ready to help you select the best product to meet your specific requirements. The availability of our products is subject to regional demand and regulations. Detailed information and certifications are available upon request.

Visit our website to learn more about our comprehensive Bio-Lubricants solutions: **www.emeryoleo.com/bio-lubricants**

For more information, contact your nearest regional office.

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