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High-performance basestock technology for automotive and industrial greases

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NLGI 90th Meeting
San Diego, California

ExxonMobil

Agenda

Grease market trends

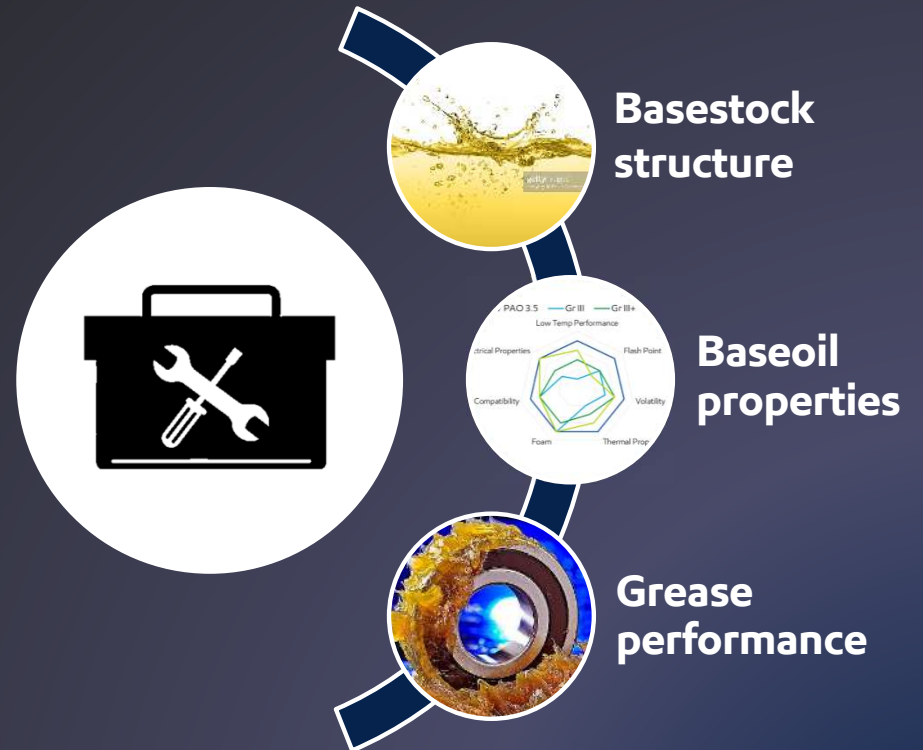
Polyalphaolefin history

Baseoil effect on finished grease applications

Expanding the formulation toolbox:

- High viscosity metallocene PAO
- Low viscosity, low volatility PAO

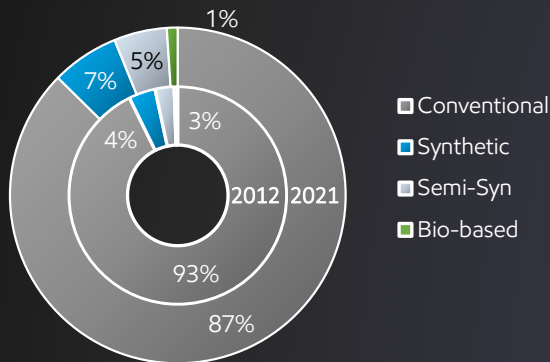
Conclusion



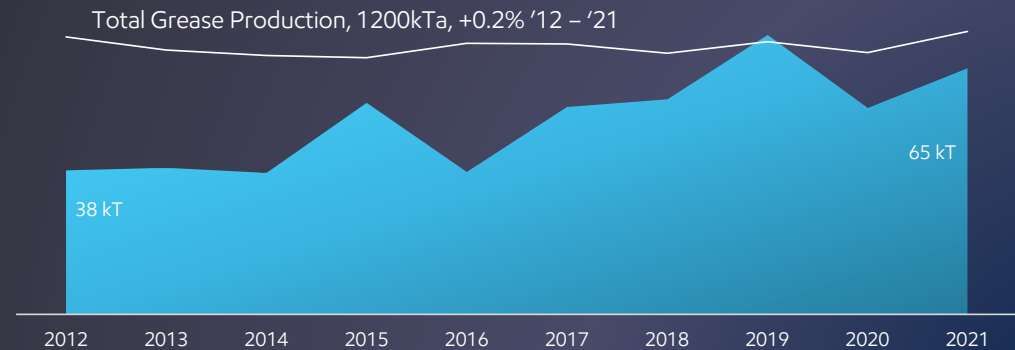
Long-term trends require innovation



Grease Production Market by Basestock Type, 2012 vs. 2021, +0.5% CAGR



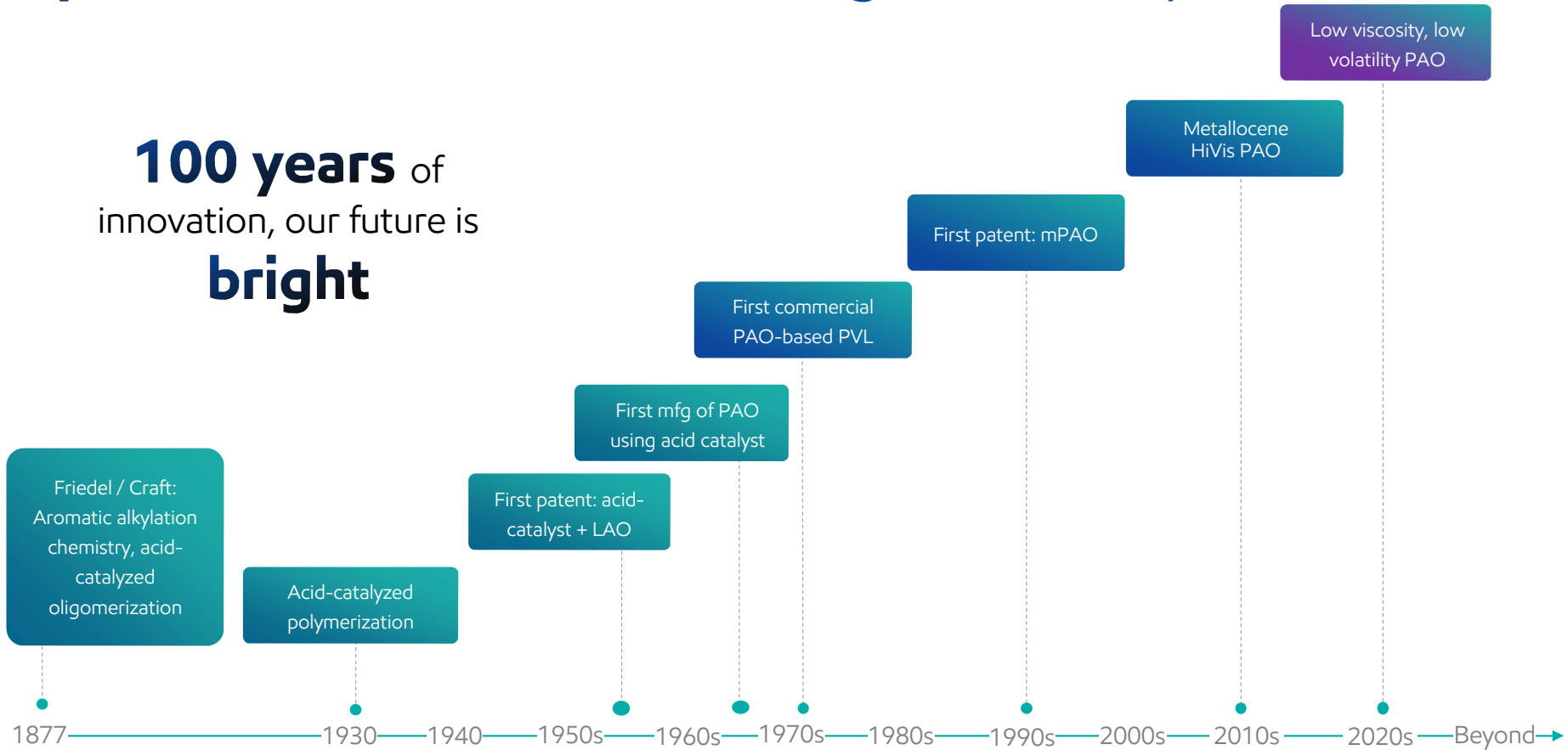
NLGI SYN Grease Production +6% CAGR '12 - '21



Source: NLGI Production Survey, "Comparative," 2015, 2016, 2018, 2020, 2021

Polyalphaolefin advancements throughout history

100 years of
innovation, our future is
bright

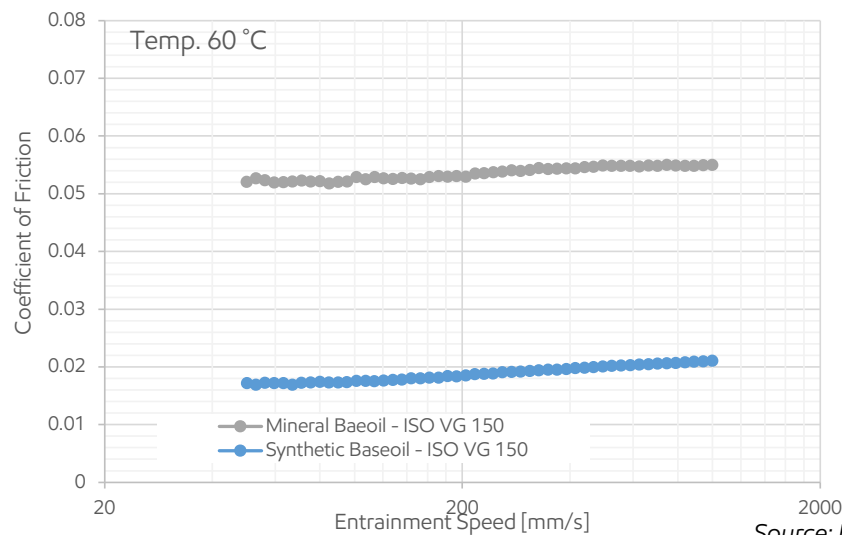


Basestock influences finished grease performance

- Basestock selection in grease applications is critical to define lubricant properties
- Primary benefits associated with the use of synthetic basestocks compared to mineral oil:
 - Improved low/high temperature properties
 - ~50% reduction in COF for finished greases across a wide range of entrainment speed

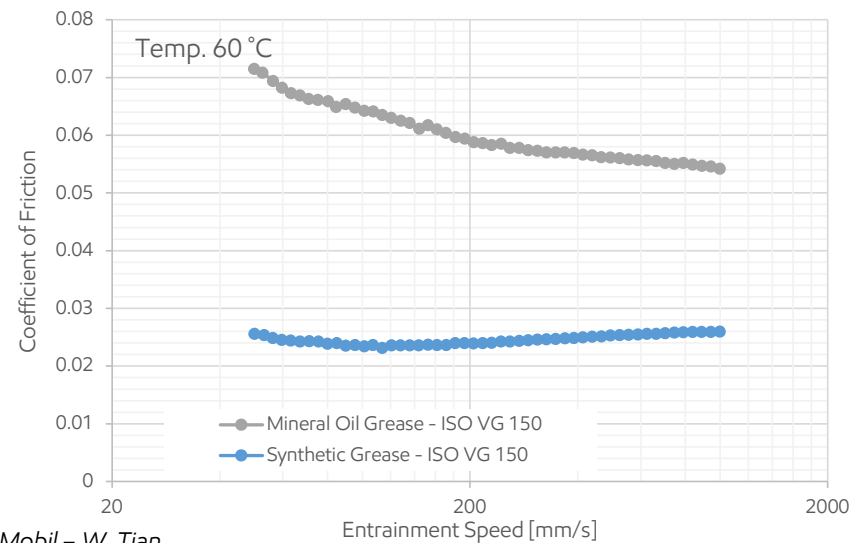


Conventional MTM – Baseoil mixture



Source: ExxonMobil – W. Tian

Modified MTM – Finished LiX grease



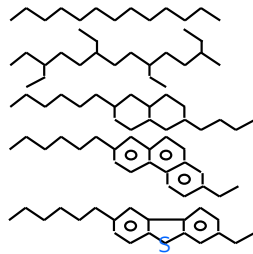
ExxonMobil

High viscosity synthetic basestocks

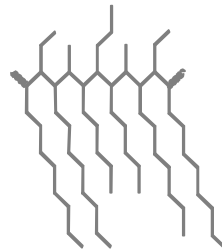
Synthetic basestock molecular science: **Metallocene PAO**

- In 2010, ExxonMobil pursued enhancements to PAO manufacturing process to leverage metallocene catalyst
- Hence, integrating the metallocene catalyst technology into PAO manufacturing process enables new molecular structure improvements:

Mineral oil

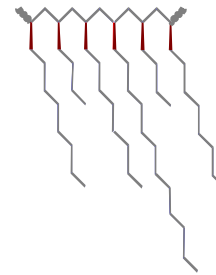


Conventional PAO



Illustrative purposes only

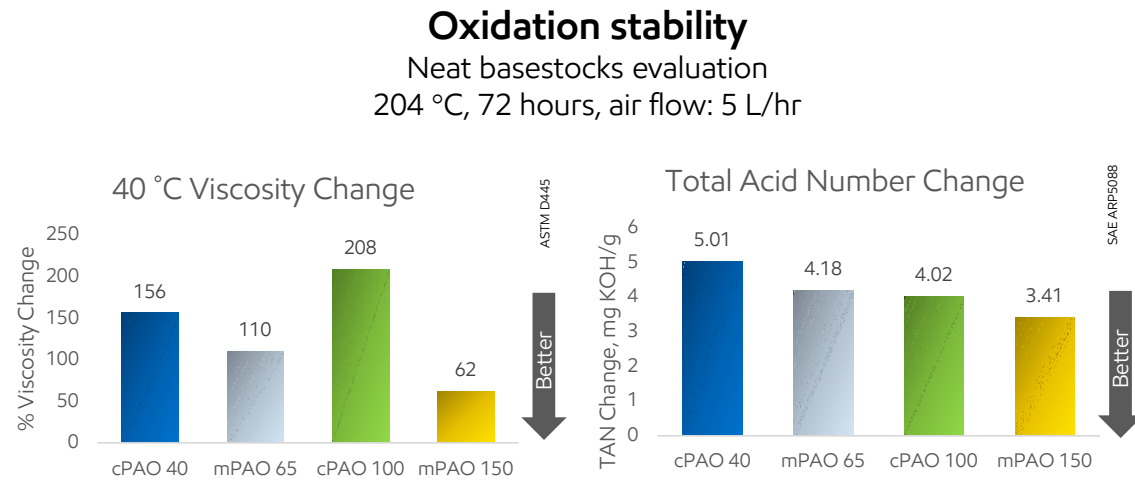
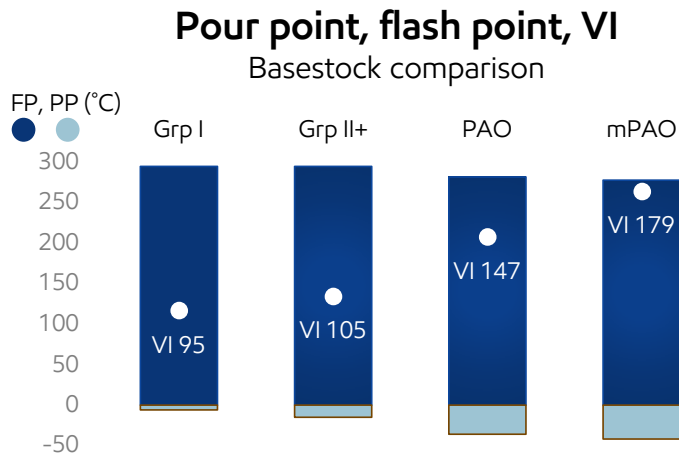
Metallocene PAO



High viscosity mPAO: Performance benefits

New structure provides benefits in several key areas for high performance grease applications:

- Low temperature performance, higher VI, Oxidative stability
- Typical high viscosity industrial grease formulations range from ISO VG 100 to 460, where synthetic basestock in combination with solubilizing co-basestock, provides the backbone for grease performance

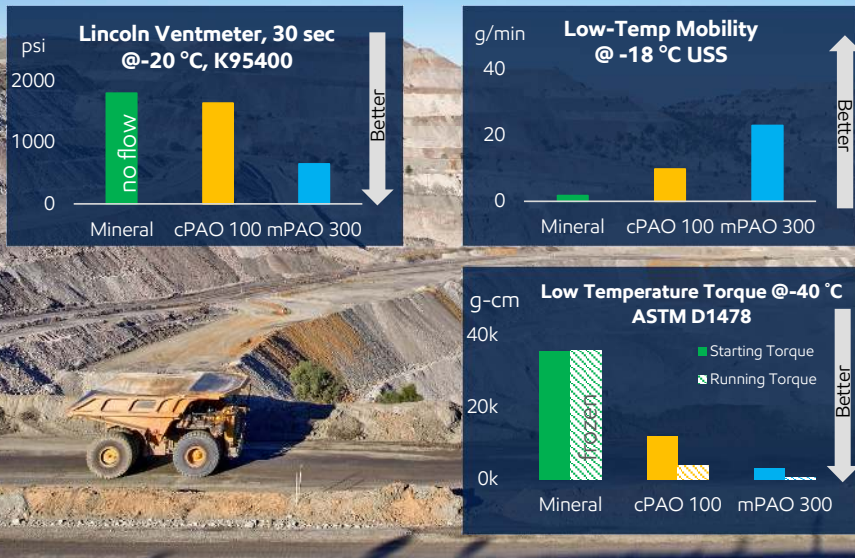


Source: ExxonMobil

ExxonMobil

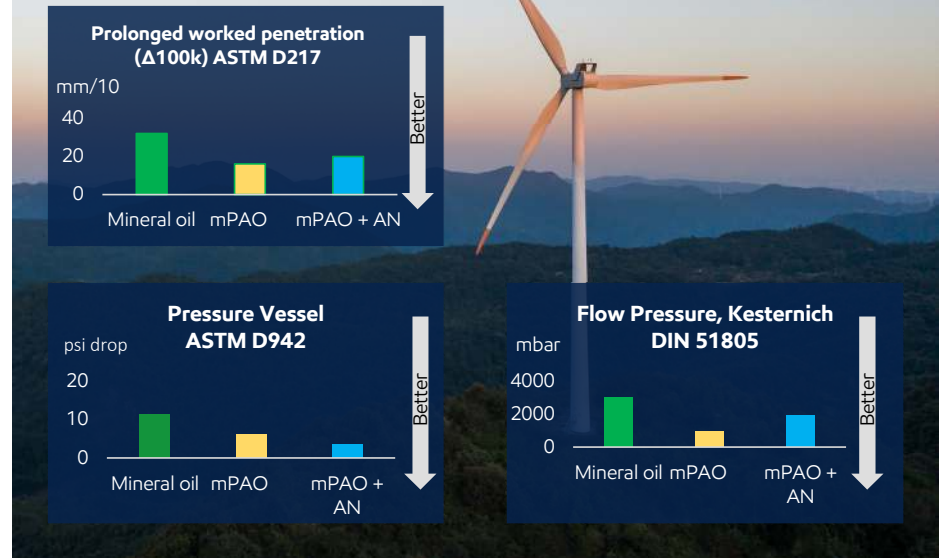
Industrial grease applications demand **high performance mPAO**

mPAO 300 + AN in CaSX, ISO VG 460*:
 Excellent low temperature properties enable to enable optimized grease lubrication in low temperature environments such as **arctic mining**



*Source: ExxonMobil - Axel Christiernsson

mPAO 150, mPAO 150 + AN LiX, ISO VG 460**:
 Enhanced shear and oxidative stability + cold flow pumpability required for **wind turbine lubrication**



**Source: ExxonMobil - Afton Chemical

Low viscosity synthetic basestocks

Overarching trend: Improve energy efficiency

ICE market trends dominated by fuel economy

Global regulations continue to be aggressive;
EU imposed emission penalties on OEMs in 2021

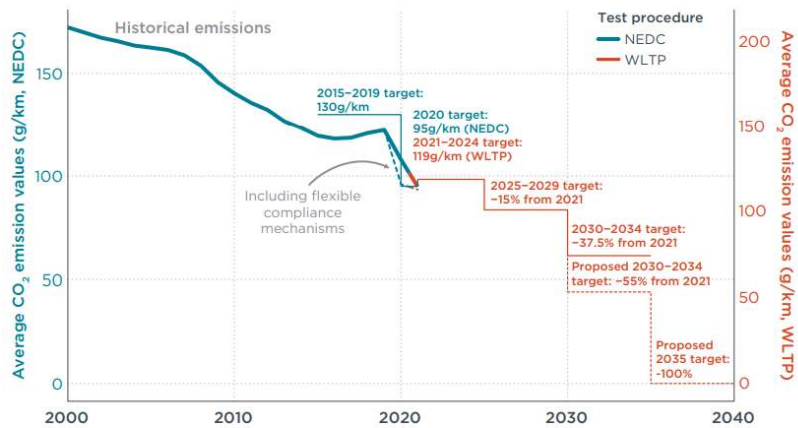


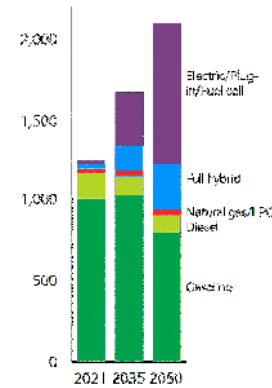
Figure 1. Historical average NEDC and WLTP CO₂ emission values and targets of new passenger cars.

Source – ICCT: <https://theicct.org/wp-content/uploads/2022/08/co2-new-passenger-cars-europe-aug22.pdf>

EV market trend focused on extending range

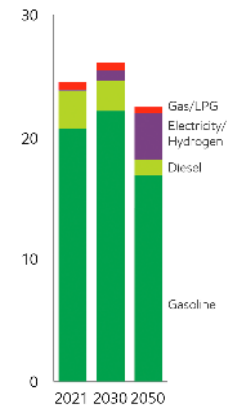
New energy efficient fluids required for e-mobility

Light-duty fleet by type
Million vehicles



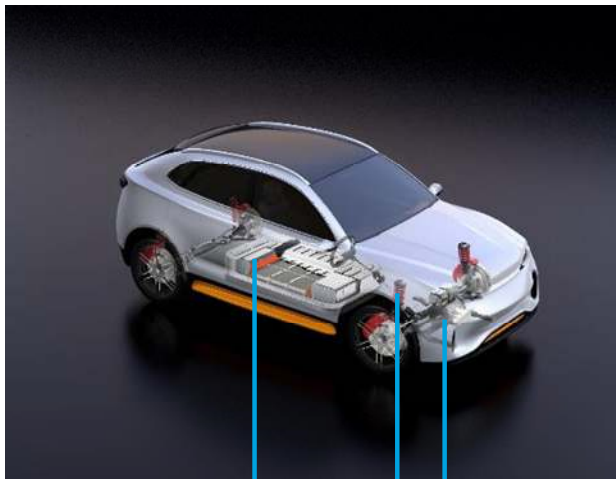
Source: ExxonMobil Energy Outlook 2022

Light-duty demand drops
Million oil-equivalent barrels per day



Low viscosity fluids enable improved energy efficiency to reduce emissions and enhance e-mobility

Evolving requirements, **new opportunities**

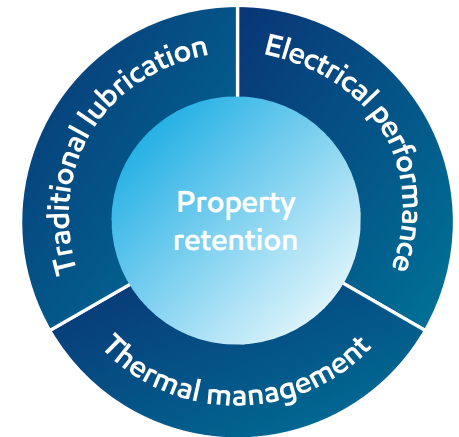


Lubrication challenges:

- High speed
- High temperature
- Long life (improved oxidative stability)
- Electrical properties
- Material compatibility

Base oil directly impacts:

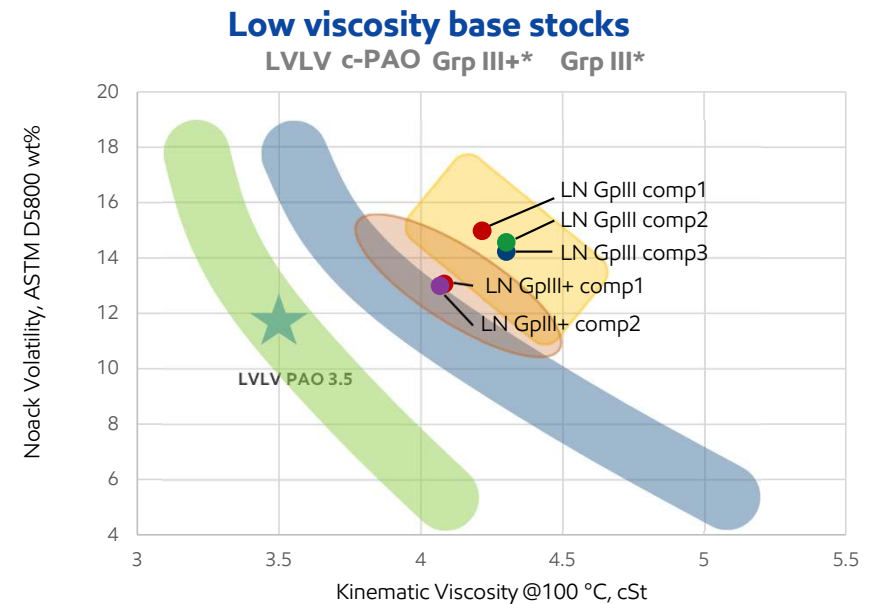
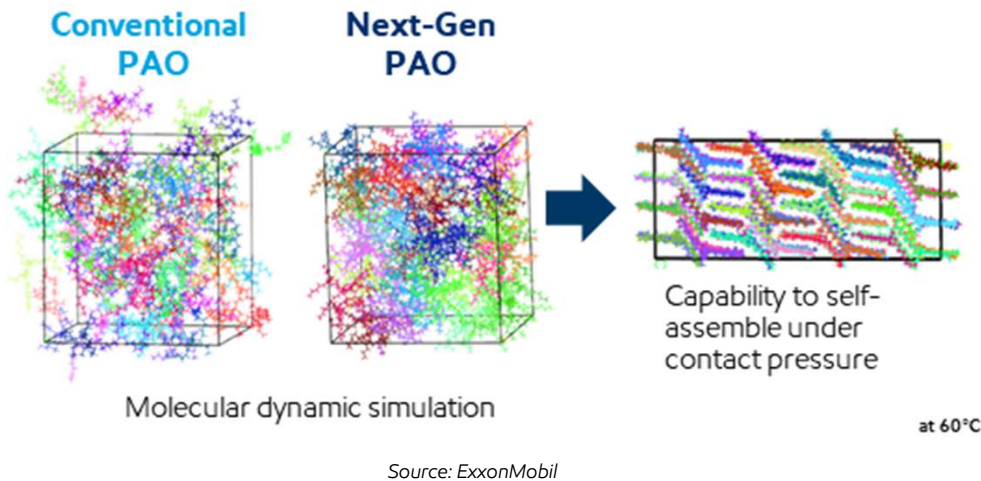
- Energy efficiency (driving range)
- Heat transfer and thermal management
- High-/low-temperature properties, oxidation stability



| | Lubrication needs | Thermal needs | Electrical needs |
|----------------------------|--|--|--|
| Electric motor | <ul style="list-style-type: none"> • Energy efficiency • Wear protection | <ul style="list-style-type: none"> • Heat transfer / cooling • Thermal stability | <ul style="list-style-type: none"> • Optimized conductivity • Material compatibility |
| Gearbox | <ul style="list-style-type: none"> • Energy efficiency • Wear protection | <ul style="list-style-type: none"> • Oxidative stability | |
| Battery/electronics | | <ul style="list-style-type: none"> • Thermal management • Safety | <ul style="list-style-type: none"> • Insulation • Material compatibility |

Low viscosity, low volatility PAO: **LVLV PAO**

- More stringent ICE / EV standards require increased stability for low viscosity basestocks
- Typical low viscosity synthetic grease formulations range from ISO VG 30 to 120, where synthetic basestock in combination with solubilizing co-basestock, provides high performance backbone for grease performance

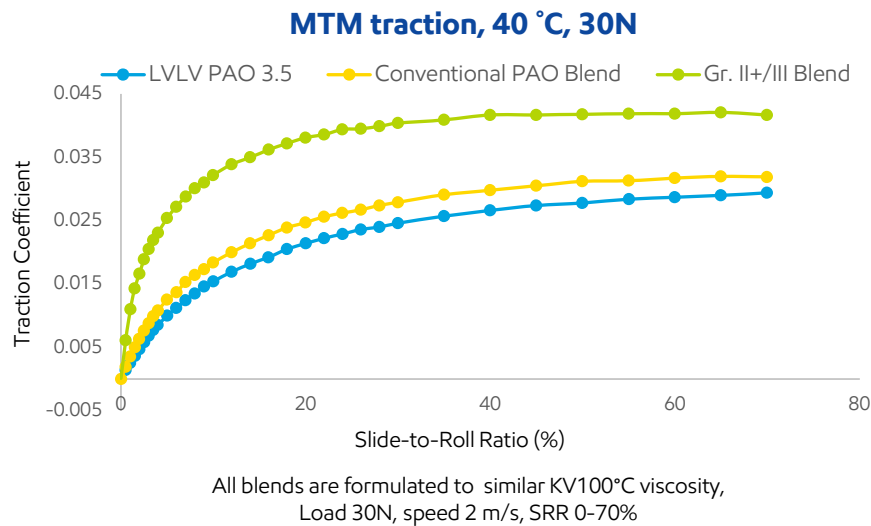


Source
LVLV PAO 3.5: ExxonMobil data
*Comparative examples: publicly available data
(KV100 and NOACK)

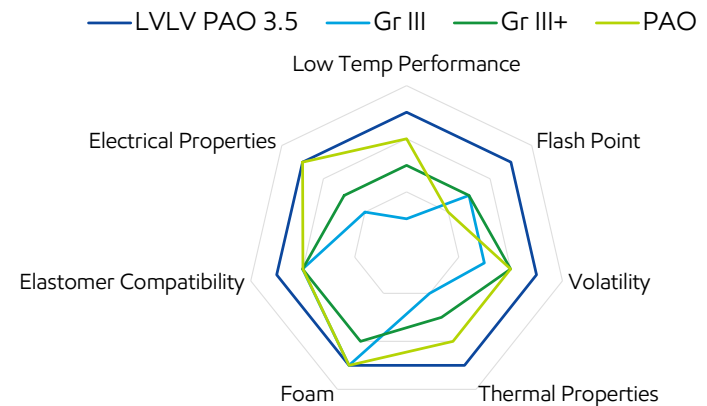
Low viscosity low volatility (LVLV) PAO: Performance benefits

LVLV PAO unique attributes:

- Exceptional low viscosity, low volatility balance, improved flashpoint versus conventional PAO (c-PAO)
- Excellent low-temperature properties, improved oxidative stability, enhanced lubricity and traction



LVLV PAO 3.5 vs. ISO-viscous base oil blends



LVLV products outperform existing GrIII-III+ and cPAO base stocks, enabling next-gen performance

Source: ExxonMobil

ExxonMobil

Trends in automotive greases require **LVLV PAO**

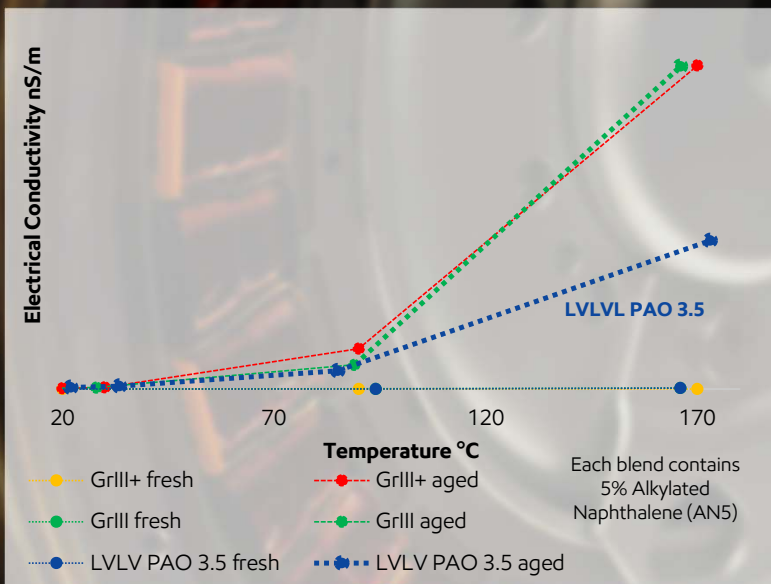


High speed bearing test rig developed by **KTH Stockholm**

Features include:

- ✓ Two heads with four Type 6208 Deep Groove ball bearings
- ✓ Axial load ~210 N, radial load ~300 N
- ✓ Variable speeds up to 600.000 nDm
- ✓ Room temperature, uncontrolled

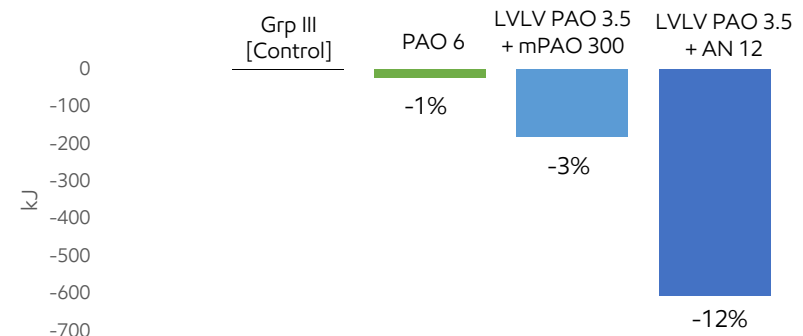
Oxidation stability and electric properties Neat basestocks



Candidates were aged following the CEC L-48 method, running for 192 hours at 170 °C

Source: ExxonMobil

Relative Energy Consumption Polyurea ISO VG 30



Source: KTH Stockholm

ExxonMobil

Conclusion

- Growth in synthetic-based greases exceeds overall grease market by 3x.
- Metallocene PAO (mPAO) enables superior performance and longer ODI for industrial applications.
- Low viscosity, low volatility PAO (LVLV PAO) offers best-in-class electrical/thermal properties, traction and therefore energy efficiency benefits in a range of low viscosity applications
- High performance synthetics basestocks are the most significant lever to improve finished grease performance across different additive and thickener systems.
- Upgrading to synthetic basestocks greases will enable the industry rise to the challenges on the horizon of this industry.

These high performance basestocks offers the ability to meet the evolving needs of grease industry

Collaboration is key to developing solutions. **Let's talk!**

Scan the QR code to get in touch with us



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Lindsey Bunting



Luca Salvi

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