



How we're making lubricants more efficient

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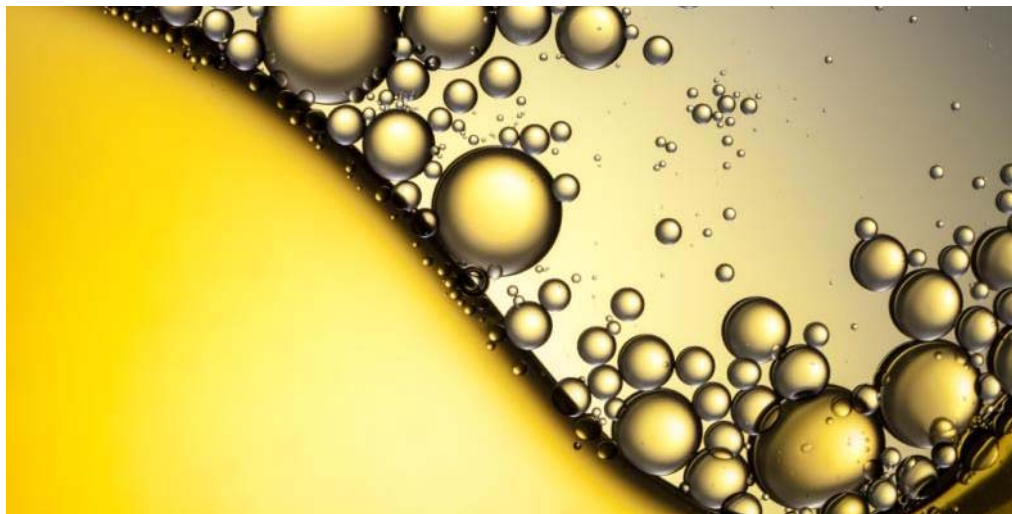
New generation of lubricant additives:

Evonik combines fuel savings with additional protection against wear and tear.

Essential levers for efficient mobility



Lubricants



Lightweight design



Tires



Keeping your engine “humming”



Lubricants

- Reduce friction and wear
- Enable transmission of force
- Provide cooling
- Dampen vibrations
- Seal
- Protect against corrosion



...and thereby also reduce fuel consumption in vehicles!

Viscosity plays a key role



Too low viscosity:

Metal parts rub against each other



Too high viscosity:

More energy required to keep the engine components moving in the lubricant

The ideal compromise varies depending on design and operating conditions

Viscosity is temperature-dependent



The challenge is to keep optimal viscosity stable across a broad range of temperatures



Modern lubricants contain temperature-sensitive thickeners



- Base oil
- Viscosity index improvers
- Wear-protection additives
- Antioxidants
- Dispersion agents



Lubricant additives can reduce fuel consumption by up to 4 percent



Engine oil: $\approx 1.9\%$



Engine

Transmission oil (automatic): $\approx 1.2\%$



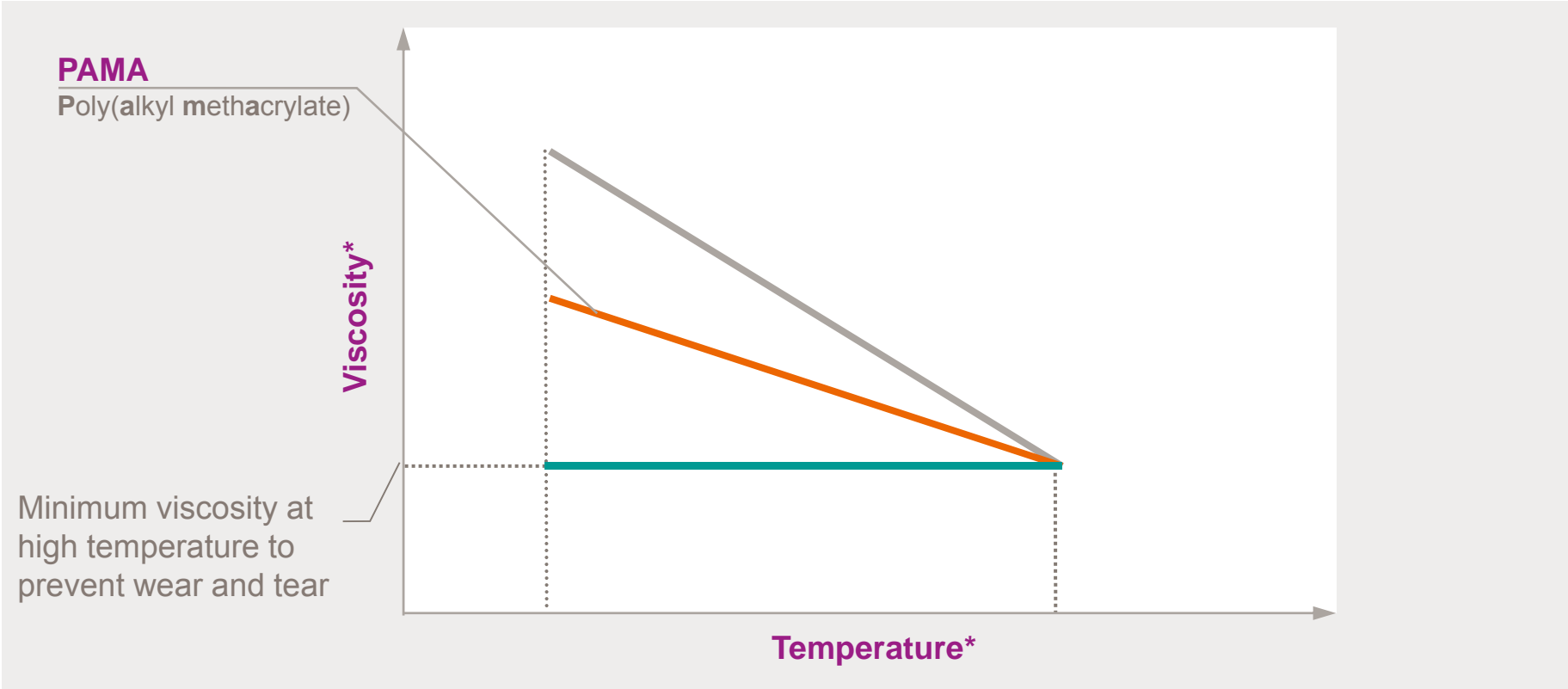
Transmission

Axle oil: $\approx 0.5\%$



Axle

Polymers as viscosity index improvers



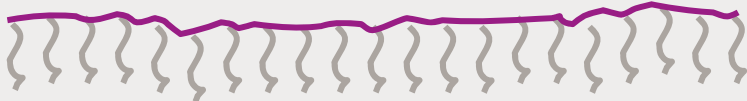
- Ideal lubricant
- Base oil
- Viscosity-modified lubricant

* linearized

PAMAs thicken the base oil



PAMA (schematic)



Monomers with side chains of 8-18 carbon atoms

Small coil
at low temperatures



Large coil
at high temperatures



New generation of comb polymers



Comb polymer (schematic)



Compact backbone with side chains of approx. 300 carbon atoms

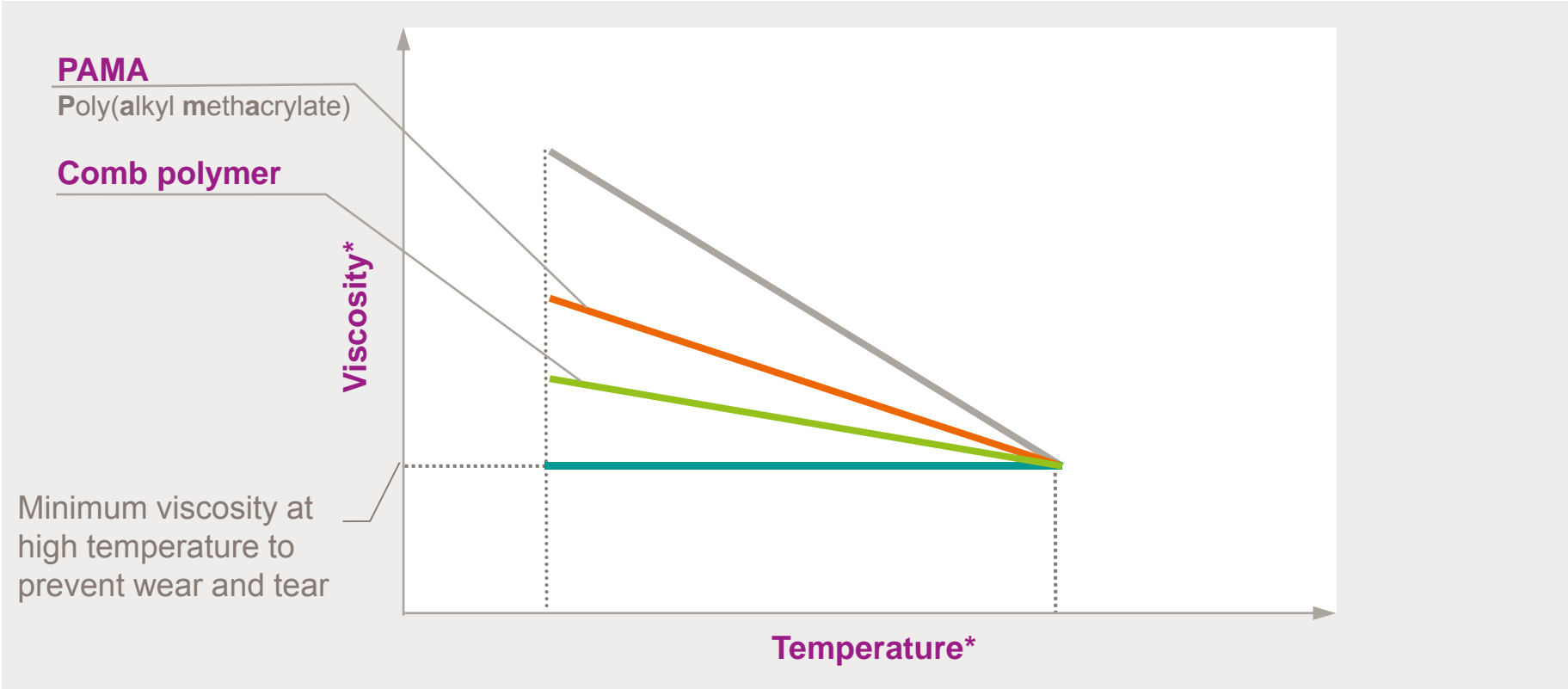
Shrunk coil
at low temperatures



Expanded coil
at high temperatures



Comb polymers—a step closer to an ideal lubricant



- Ideal lubricant
- Base oil
- Viscosity-modified lubricant with PAMA
- Viscosity-modified lubricant with comb polymers

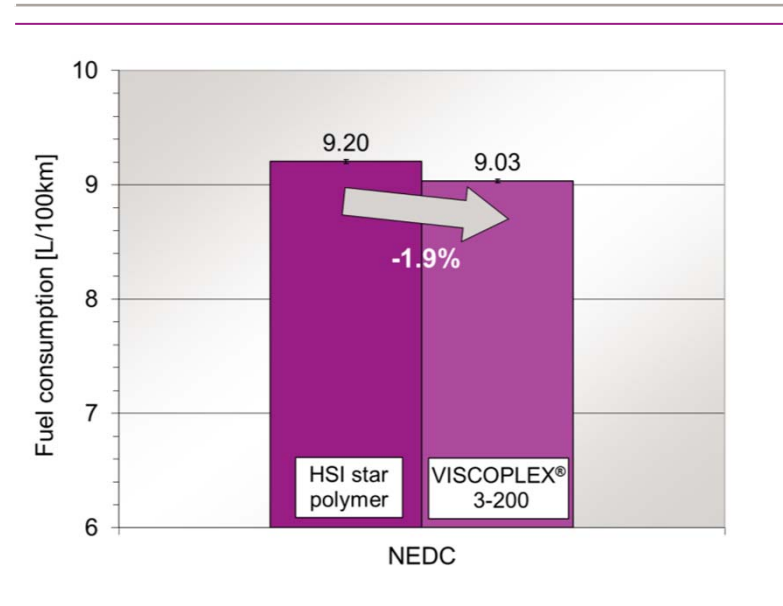
* linearized

Comb polymers reduce fuel consumption



Laboratory tests with powerful engines (215 kW@6400 rpm):

- Lubricant with VISCOPLEX[®] 3-200 reduces fuel consumption by 1.9% compared to styrene-isoprene-based competitor products
- Viscosity-reducing effect up to -40°C leads to better engine start-up response in winter conditions



NEDC: New European Driving Cycle

Total cost advantage based on comb polymers



Savings for car manufacturers

| | |
|-----------------|------------------------------|
| 2015 basis: | 130 g CO ₂ /km |
| 2020 objective: | 95 g CO ₂ /km |
| EU penalty: | €95 per g of CO ₂ |

€400 per vehicle for new vehicles in the EU

Savings for consumers

| | |
|--------------------------|--------------|
| Fuel consumption: | 6.0 l/100 km |
| Vehicle life expectancy: | 200,000 km |
| Price of gasoline: | €1.50/l |

€630 per vehicle over the entire lifecycle

Comb polymers with additional surface-active properties



VISCOPLEX® 12-209

As a comb polymer:

Viscosity improvement

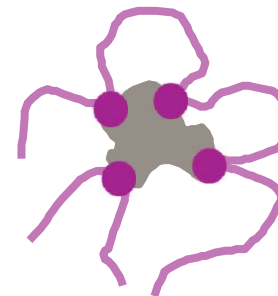
Fuel savings

By integration of surface-active anchor groups:

Lubricating polymer film on the metal surface

Keeps oxidation products in suspension

Extended life expectancy of drivetrain components and lubricant



Guidance for Lubricant manufacturers

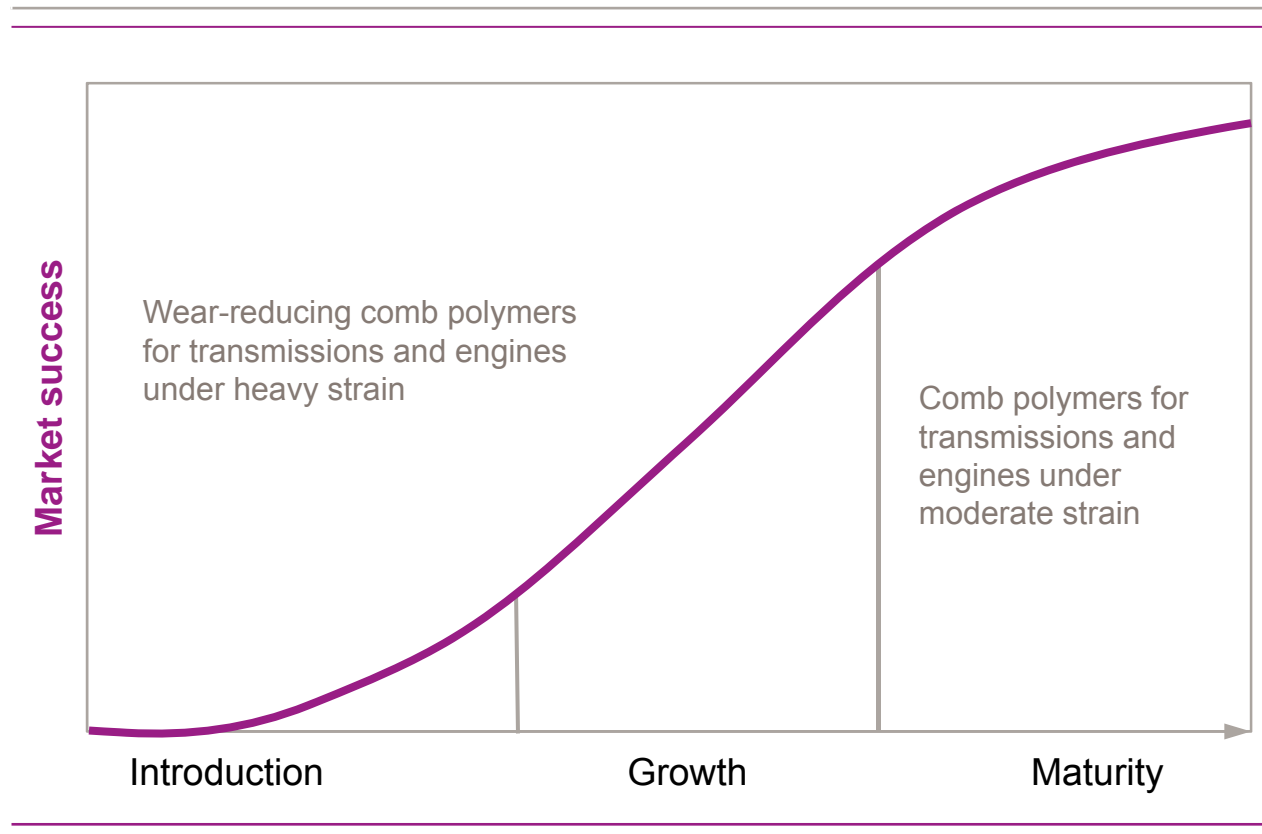


Evonik is marketing its lubricant additives—including formulation assistance and services for durable, fuel-efficient automotive drivetrain components—under the brand name DRIVON™ technology



DRIVON™

Technology platform is under continuous development





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