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: ≈1.9%
Transmission oil (automatic): ≈1.2%
Axle oil: ≈0.5%
Polymers as viscosity index improvers

Minimum viscosity at high temperature to prevent wear and tear

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

Shrunken coil at low temperatures

Expanded coil at high temperatures
Comb polymers—a step closer to an ideal lubricant

PAMA
Poly(alkyl methacrylate)

Comb polymer

Minimum viscosity at high temperature to prevent wear and tear

Viscosity

Temperature

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

* linearized

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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

<table>
<thead>
<tr>
<th></th>
<th>Savings for car manufacturers</th>
<th>Savings for consumers</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2015 basis:</td>
<td>Fuel consumption: 6.0 l/100 km</td>
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<tr>
<td></td>
<td>130 g CO₂/km</td>
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<tr>
<td></td>
<td>2020 objective:</td>
<td>Vehicle life expectancy: 200,000 km</td>
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<tr>
<td></td>
<td>95 g CO₂/km</td>
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<td></td>
<td>EU penalty:</td>
<td>Price of gasoline: €1.50/l</td>
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<td>€95 per g of CO₂</td>
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€400 per vehicle for new vehicles in the EU

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

Wear-reducing comb polymers for transmissions and engines under heavy strain

Comb polymers for transmissions and engines under moderate strain

Introduction  Growth  Maturity