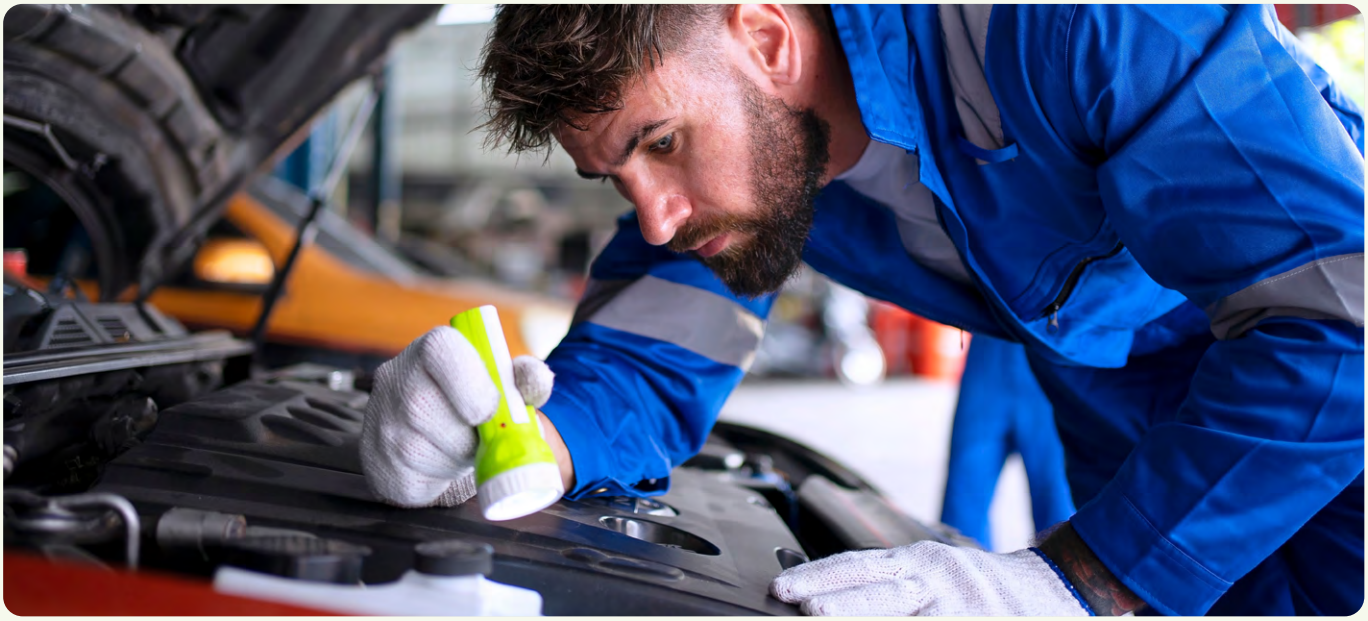
Cargill

Energy Technologies

Solutions for internal combustion engine and hybrid passenger cars

Cargill's high-performance lubricant solutions empower formulators to achieve better fuel economy, lower friction and superior durability for internal combustion engine (ICE) and hybrid passenger cars.

Navigating complexity: trends and requirements for ICE and hybrid passenger car lubricants



The automotive lubricant market is evolving rapidly under regulatory changes, OEM requirements and consumer expectations. Formulators face increasing complexity as they strive to meet:

- **Fuel economy and emissions compliance:** Stricter CO_2 reduction targets and fuel efficiency standards demand low-viscosity oils and advanced friction control technologies.
- **Hybrid powertrain challenges:** Frequent stop-start cycles and lower operating temperatures increase stress on lubricants, requiring superior friction control, water management and wear protection.
- **Advanced transmission systems:** Modern gearboxes and hybrid drivetrains require fluids with excellent friction control, wear protection , material compatibility and low-temperature fluidity.
- **Extended drain intervals and durability:** Oils and transmission fluids must maintain performance over longer service periods without compromising oxidation stability or cleanliness.
- **Low-SAPS formulations:** Protecting emission control systems while delivering anti-wear performance is critical for compliance with global specifications.
- **Sustainability and renewable content:** OEMs and consumers expect sustainability in-use benefits, including bio-based components.
- **Fuel quality and additive needs:** Modern ICE and hybrid engines rely on fuels that meet stringent cleanliness and lubricity standards. Fuel additives play a critical role in improving lubricity, reducing friction, preventing corrosion, and supporting compatibility with biofuels.

Formulating your next generation lubricant solutions

Whether you are formulating a new engine oil, transmission lubricant or other automotive fluid having the right componentry and base oil is essential.

Cargill offers a comprehensive range of ester base fluids and friction modifiers to help you to design high-performance lubricants and fuel packages that meet stringent OEM and regulatory standards for both traditional internal combustion engine (ICE) and hybrid passenger cars.

With over four decades of experience supporting the automotive industry, our team of technical specialists delivers the expertise needed to guide you in product selection and treat-rate optimization, enabling you to achieve peak performance in your formulations.

Cargill's portfolio for traditional internal combustion engine (ICE) and hybrid passenger cars offers the essential components to develop lubricants that can enhance durability and improve fuel efficiency. In addition, the majority of our products are bio-based, supporting the transition from mineral oil to plant-based alternatives.

Priolube™ synthetic esters are engineered for use across a wide range of automotive lubricants. In engine oils, they deliver enhanced thermal stability, support extended drain intervals, and improve cold-start reliability - with certain grades containing up to 87% bio-based content. In transmission fluids, Priolube synthetic esters help ensure excellent low-temperature performance, high efficiency and extended drain intervals.

Perfad™ friction modifiers significantly reduce friction and optimize fuel economy in engine oils, with certain grades offering up to 100% bio-based content. In wet clutch applications, they are able to modify friction to prevent shudder and slip.

Complementing these technologies, **Cargill's fuel additives** can improve lubricity, boost fuel economy, prevent corrosion, and maintain fuel clarity – supporting more efficient and reliable fuel system performance.

Passenger car engine oils

Priolube™ synthetic esters

To support your formulation needs, we offer a diverse range of esters that can be used as additive solubilizers and seal swell agents, or as base fluids in the formulation of passenger car motor oils (PCMO) and racing fluids.

Key benefits:

- High viscosity index & low volatility for thermal stability and extended drain intervals
- Excellent low temperature fluidity for reliable cold-start performance
- Excellent additive solubilization properties
- Up to 87% bio-based content

Product range:

Product	Key specifications							Regulatory compliance and sustainability	
	Kinematic viscosity at 40°C (mm²/s)	Kinematic viscosity at 100°C (mm²/s)	Viscosity index	Pour point (°C) ASTM D7346	Flash point (°C) ASTM D92	Noack volatility at 250°C (%) ASTM D5800-B	Non polarity index (NPI)[c]	Readily biodegradable OECD 301B	Bio-based carbon content (%)
Priolube™ 1936	26	5.3	139	-54	244	5.8	82	•	0[b]
Priolube™ 1973	46	8	148	-44	280	1.7	130	•	87[a]
Priolube™ 1976	26	5.4	157	-35	260	3.8	216	•	48[a]
Priolube™ 3963	11.5	3.2	149	-78	230	14.6	55	•	38[b]
Priolube™ 3967	94	13	145	-45	290	2.9	201	•	70[a]
Priolube™ 3970	20	4.4	140	-51	250	3	60	•	81[a]
Priolube™ 3999	90	14	144	-27	290	1.7	195	•	87[a]

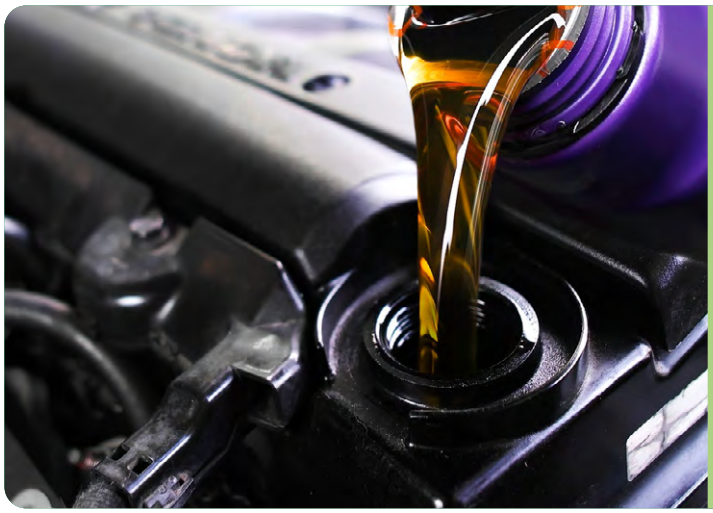
[a] According to ASTM D6866

[b] Calculated based on molecular structure

[c] NPI is an indicator of the polarity of an ester; a lower number represents higher polarity and a higher number represents lower polarity.

Organic friction modifiers

Different engine oil formulations may require tailored friction modifier solutions to achieve optimal performance in terms of frictional properties and wear. Drawing on over 40 years of expertise in ester and amide technology, Cargill has developed a broad range of products with no intentionally added sulphated ash, phosphorus, or sulfur, making them well suited for use in engine oils. These additives are typically used at treat rates between 0.5-1 w/w%.



Key benefits:

- Outstanding friction reduction: up to 90% in boundary lubrication regimes
- SAPS-free for low-SAPS formulations protecting emission systems
- Durable film formation to help minimize wear
- Synergy with inorganic additives for balanced performance
- Help improve ASTM D7563-23 Emulsion Retention test performance

Product range:

Product	Key specifications					Regulatory compliance and sustainability	
	Pour point (°C) ASTM D7346	Flash point (°C) ASTM D92	Hydroxyl value (mgKOH/g) ASTM D1957	Acid Value (mgKOH/g) ASTM D664	Iodine value (gI/ 100g)	Readily biodegradable OECD 301B	Bio-based carbon content (%)
Optislip™ O	Pastille (melt point 69°C)	-	9	-	90	•	95[a]
Perfad™ 3006	4	269	50	1.2	5		78[a]
Perfad™ 3057	3	280	22	1.2	4.7		24.5[b]
Perfad™ 4000[d]	-30	220	131	2.0	10		80[a]
Perfad™ FM 3336	-25	>220	204	1	5	•	100[a]
Perfad™ NG 2500	-11	>250	>35	1.0	4		100[a]
Priolube™ 1407	0	215	220	0.1	79	•	100[a]

[a] According to ASTM D6866
[b] Calculated based on molecular structure
[d] Only available in North America

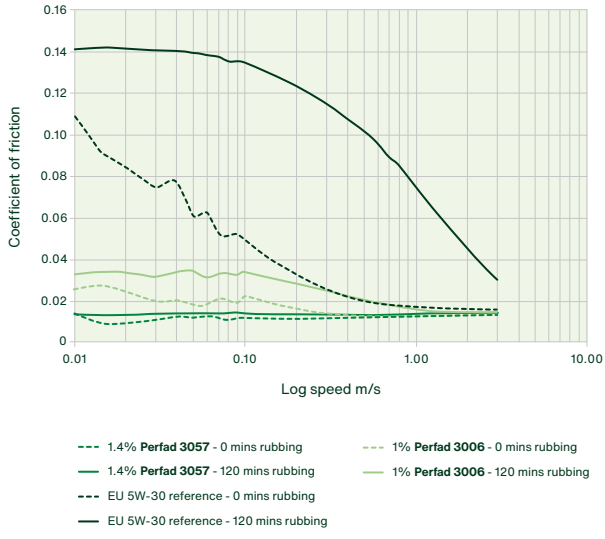
Proven fuel economy and efficiency improvement

Adding Perfad 3057 or 3006 to a non-optimized 0W-20 oil delivers a notable boost in fuel economy performance, raising FEI from 2.41% to 3.37% in the Sequence VI-E test used for API SP and ILSAC GF-6/GF-7.

	FEI 1 (%)	FEI 2 (%)	FEI sum (%)	Polymeric friction modifier contribution
Reference Oil (0W-20)	1.09	1.32	2.41	-
Ref Oil + 0.7% Perfad 3057	1.69	1.42	3.11	0.70
Ref Oil + 0.5% Perfad 3006	2.02	1.35	3.37	0.96

Table 1: Sequence VI-E engine oil test results achieved using polymer friction modifiers for a non-optimized 0W-20 engine oil. FEI 1 looks at fuel economy after a short period of aging while FEI 2 considers oil performance after extended aging.

Adding Perfad™ 3057 and Perfad™ 3006 to a European 5W-30 reference oil significantly reduces the coefficient of friction, demonstrating the efficiency gains enabled by Perfad friction modifiers.



Graph 1: MTM Stribeck curve at 36N, 50% SRR at 130°C before and after 120 mins rubbing at 32N 0.05m/s

Transmission lubricants (ATF and DCT)

Priolube™ synthetic esters

Cargill offers a range of esters that can be used as additive solubilizers and seal swell agents, which can improve low temperature properties and Brookfield (-40°C) performance. Our product range also supports control and durability of friction in wet clutch systems, as well as offering formulators the potential to increase the bio-based content of finished fluids.

Key benefits

- High VI and thermal stability for modern gearboxes
- Low-temperature fluidity for cold start performance
- Bio-based content
- Extended clutch fluid lifetime

Product range

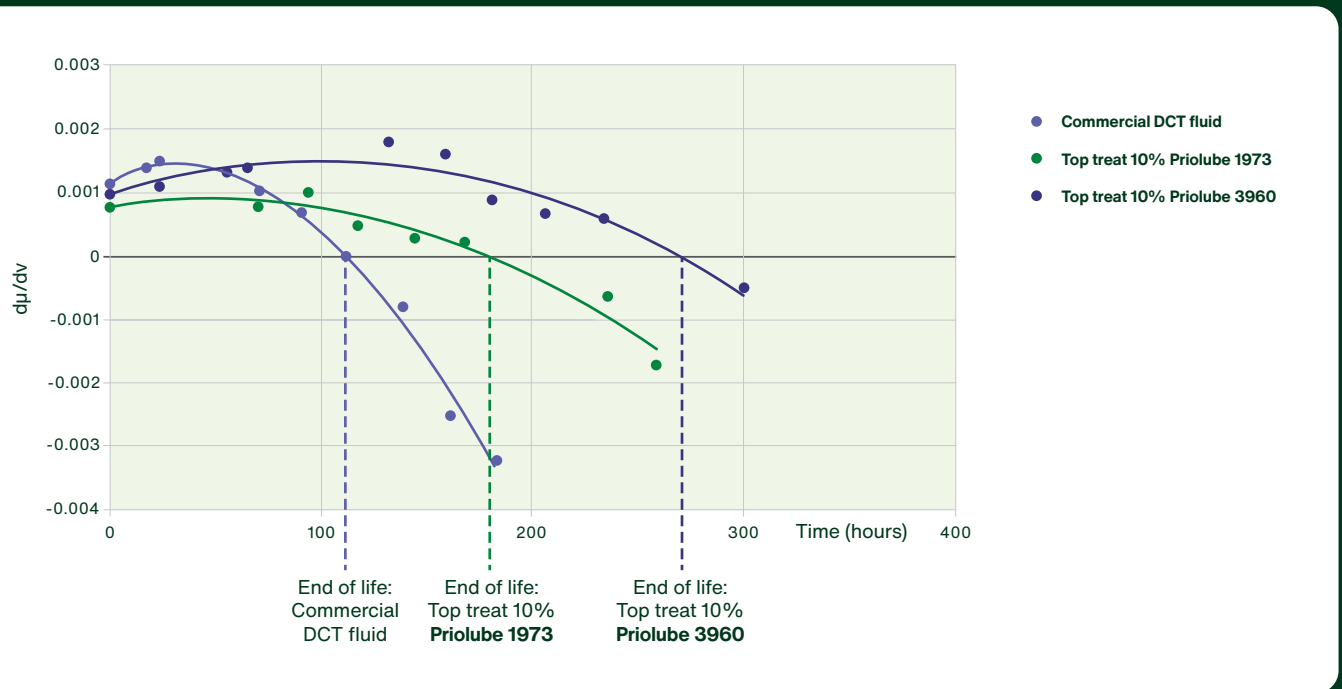
Product	Key specifications					Regulatory compliance and sustainability	
	Kinematic viscosity at 40°C (mm²/s)	Kinematic viscosity at 100°C (mm²/s)	Viscosity index	Pour point (°C) ASTM D7346	Flash point (°C) ASTM D92	Readily biodegradable OECD 301B	Bio-based carbon content (%)
Priolube™ 1847	1040	90	167	-24	292	•	81[a]
Priolube™ 1929	1700	125	175	-21	310		80[a]
Priolube™ 1935	14.5	3.7	149	-72	226	•	0[b]
Priolube™ 1936	26	5.3	139	-54	244	•	0[b]
Priolube™ 1973	46	8	148	-44	280	•	87[a]
Priolube™ 2046	400	40	163	-36	310		85[a]
Priolube™ 3958	10.5	3	146	-78	215	•	38[a]
Priolube™ 3960	19	4.5	163	-72	230	•	33[a]
Priolube™ 3963	11.5	3.2	149	-78	230	•	38[b]
Priolube™ 3970	20	4.4	140	-51	250	•	81[a]
Priolube™ 3986	47000	2000	278	6	325		85[a]
Priolube™ 3997	40000	2000	290	6	327		82[a]

[a] According to ASTM D6866

[b] Calculated based on molecular structure

Clutch fluid life extension with Priolube esters

Choosing the right Priolube™ ester makes a major difference in dual clutch transmission durability. Top-treating a commercial DCT fluid with Priolube™ 1973 and Priolube™ 3960 extended fluid lifetime by 60% and 100% respectively, based on positive dμ/dv performance.



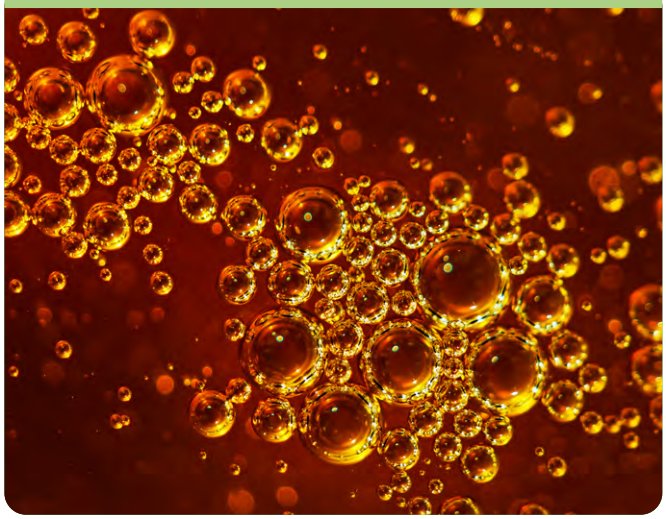
Graph 2: DCT fluid life extension through top treating with Priolube esters

Organic friction modifiers

Cargill's range of friction modifiers consistent of organic FMs that are free from intentionally added SAPS (sulphated ash, phosporous and sulphur) and are used to reduce friction and wear in automotive transmission applications. These additives are normally included in formulations at between 0.5-1 w/w%.

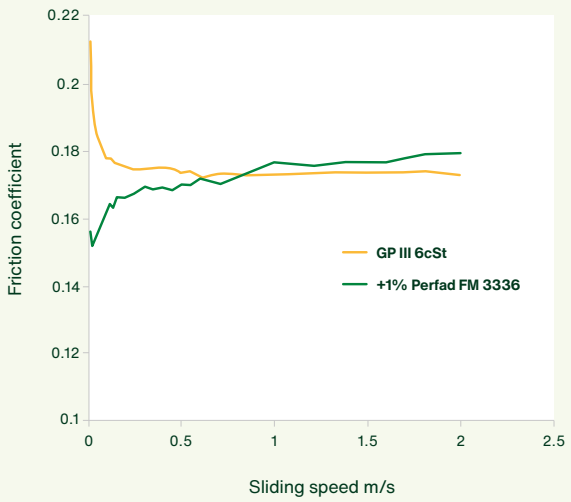
Key benefits

- Friction control
- Stable performance
- High-temperature resistance
- Reduced friction loss
- Formulation flexibility



Optimized friction control with Perfad friction modifiers

Adding 1% Perfad™ FM 3336 lowers low-speed friction and delivers a more stable friction profile across sliding speeds, supporting smoother and more efficient clutch operation.



Graph 3: Change in the friction of a mineral oil by the addition of Perfad™ FM 3336 friction modifier on a steel-clutch paper contact.

Product range

Product	Key specifications			Regulatory compliance and sustainability	
	Pour point (°C) ASTM D7346	Flash point (°C) ASTM D92	Hydroxyl value (mgKOH/g) ASTM D1957	Readily biodegradable OECD 301B	Bio-based carbon content (%)
Perfad™ 3006	4	269	50		78[a]
Perfad™ 4000[d]	-30	220	131		80[a]
Perfad™ FM 3336	-25	>220	204	•	100[a]
Priolube™ 1407	0	215	220	•	100[a]
	Melt point (°C)		**Hydroxyl value (mgKOH/g)**	**Biodegradable OECD 301B (>60%)**	**Bio-based carbon content (%)**
Optislip™ O	69	-	9	•	95[a]

[a] According to ASTM D6866
[b] Calculated based on molecular structure
[d] Only available in North America

Fuel additives

Gasoline and diesel fuels require additives to reduce friction and wear. Our range of fuel additives address the key needs of this market.

Key benefits

- Lubricity improvers for diesel: protect fuel pumps and injection systems in ultra-low-sulfur fuels
- Organic friction modifiers for gasoline: reduce friction and wear to improve fuel efficiency and lower CO_2 emissions
- Corrosion inhibitors: prevent corrosion and maintain fuel clarity across the supply chain
- Compatibility with biofuels: ensures performance in ethanol and biodiesel blends

Product range

Function	Product	Key specifications					Regulatory compliance and sustainability	
		Pour point (°C) ASTM D7346	Iodine value (gI/100g)	Hydroxyl value (mgKOH/g) ASTM D1957	HLB value	Acid Value ASTM D664	Readily biodegradable OECD 301B	Bio-based carbon content (%)
Corrosion inhibitor & rust preventative	Pripol™ 1017	-	95	-	-	193	•	100[a]
	Pripol™ 1025	-	-	-	-	194	•	100[b]
Diesel lubricity additive	Perfad™ FA 3340	-29	124	120	-	1.4		94.7[b]
Emulsifier	Celevida™ 6300	-	-	-	5.5	-		60[a]
	Celevida™ 6400	-	-	-	8	-		-
Friction modifier	Optislip™ O	-	25	-	-	-	•	95[a]
	Perfad™ FM 3336	-25	4	204	3	1	•	100[a]
	Priolube™ 1407	0	79	220	-	0.5		100[a]
Lubricity additive	Priolene™ 6907	-	-	-	-	-	•	100[a]

[a] According to ASTM D6866 [b] Calculated based on molecular structure

Wear reduction with Perfad™ friction modifiers

Figures 1 & 2 show the HFRR (high frequency reciprocating rig) ASTM D6079 results, with increased areas of yellow and/or red indicating a wider and deeper wear scar. The wear scar reduces from 638 µm to 252 µm when using diesel containing 150ppm of Perfad™ FA 3340 friction modifier compared to a diesel without Perfad™ friction modifier.

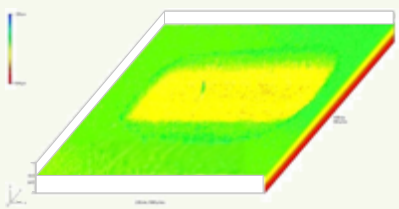


Figure 1

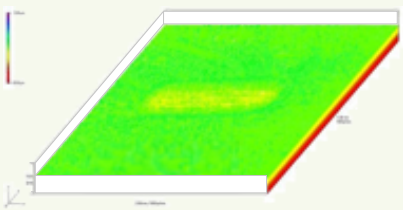


Figure 2

Let's solve what's next – *together*

Whether you're optimizing performance, or tackling formulation challenges, our technical experts are here to help. Connect with us to explore tailored solutions that meet your specific needs.

Scan QR code
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Learn more at **cargill.com/ice-hybrid-pc-oils**
or email **energy_technologies@cargill.com**

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