

Biobased Additives



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FUNCTIONAL PRODUCTS INC.

Since 1985, Functional Products Inc. has been a leading supplier of innovative polymer additives for lubricants and grease.

Functional Products Inc. manufactures market general components as well as unique, tailor-made additive solutions through development projects with clients. FPI produces over 300 standard or custom products from one drum to tanker batches.

All clients – from small blenders to multi-national corporations – receive world-class support on the necessary technologies, formulations, and regulations from experts on staff to succeed on their projects.

FPI's headquarters, offices, labs, and production are located in Macedonia, Ohio, USA. For global sales and warehousing, contact sales@functionalproducts.com or refer to page 2 of the **Applications Chart**.

Mission Statement

“Functional Products Inc. is committed to providing our customers with quality products and services that meet or exceed their expectations through the use of continuous improvement.”

FPI is proud to maintain an ISO 9001:2015 (with design) quality management system and complies with all REACH and CLP regulations, including the Globally Harmonized System (GHS) for labeling.

Health and Safety

The product descriptions, labels, and datasheets (TDS) are not intended to take the place of a Safety Data Sheet (SDS).

SDS are available online or requested at: sds@functionalproducts.com

Biobased Additives

‘Biobased additives’ are intended to support the development of biobased, biodegradable, and/or more sustainable lubricants and greases. Biobased additives may not be biobased or biodegradable as concentrates.

Functional Products Inc. has long supported the specialty lubricant market around biobased and biodegradable formulations. Government programs include:

- USDA BioPreferred Program – intended to provide more biobased content in consumer and federally approved products
- European Ecolabel Program for Lubricants – governs the development of environmentally acceptable, non-toxic, and biodegradable lubricants and greases; slight emphasis on biobased content
- US EPA Cleangredients Program – focuses on safer consumer goods with minimal hazard labeling and environmental impact (previously Design for the Environment)
- US Vessel General Permit (VGP) Program – specifies the requirements for biodegradable lubricants and greases for use on waterways

Excellence in Lubrication

Functional Products Inc. is an active member or participant in the following professional technical organizations:

STLE • ILMA • NLGI • ELGI • NLGI-IC • CLGI • K-STLE • AOCs • UEIL • Lube Expo

and supporter of university programs in lubrication and tribology.

Functional Products Inc. has received best technical paper awards at:

ELGI (Paris, 2011)	NLGI (Coeur d'Alene, 2018)
NLGI-IC (Amritsar, 2018)	CLGI (Wuyishan, 2011)

Functional Products Inc. was noted as an ‘HPM Valuable Contributor’ for the NLGI High Performance Multiuse Grease Specification (2020).

Scientists from FPI authored the chapter “Tackifiers and Antimisting Additives” in *Lubricant Additives: Chemistry and Applications*, 2nd ed. (2009) and 3rd ed. (2017), edited by Leslie R. Rudnick; and helped edit the *NLGI Lubricating Grease Guide*, 7th ed. (2022).

Biobased Viscosity Modifiers

Functional Products Inc. has been developing cost effective viscosity modifiers and thickeners for the biobased lubricant market for over a decade. Viscosity modifiers are high molecular weight polymers which are prepared in biodegradable oil to maximize biodegradable content.

The top viscosity modifiers in any new formulation project are:

FUNCTIONAL V-515

Economic and Tacky

- Bar & chain oils, saw guide oils
- Rock drill and pneumatic oil
- Total loss lubricants and greases



FUNCTIONAL V-515 is the most efficient viscosity modifier for adding viscosity to biobased lubricants with low treat and good economics. The high molecular weight also provides some tack and ant-misting performance.

FUNCTIONAL V-521

Low Temperature

- Mobile equipment, municipal vehicles
- HETG and HEES hydraulic fluid
- Low pour point base oils (TMPTO)



FUNCTIONAL V-521 is an ideal option for general purpose biobased lubricants which will experience a wide range of environmental conditions. **FUNCTIONAL V-521** adds viscosity without greatly affecting low temperature properties like pour point and is ideal in low pour point esters like TMPTO.

FUNCTIONAL V-508

Versatile, High Temperature

- NSF H1 incidental food contact
- Oven oils, smokeless oils, metalworking
- Biobased NLGI greases
- Synthetic ester and PAG oils



FUNCTIONAL V-508 is the most versatile viscosity modifier for synthetic esters and is compatible in a wide range of different polyol esters, complex esters, or even blown oils. **FUNCTIONAL V-508** has excellent thermal and oxidative stability for high temperature applications and meets NSF HX-1 and Ecolabel LuSC status.

FUNCTIONAL PD-585

Shear Stable PMA

- Full synthetic ester formulas
- Light duty gear oils
- Low temperature vegetable oil HF



FUNCTIONAL PD-585 is a multi-functional polymethacrylate (PMA) viscosity modifier for synthetic biobased lubricants at 2-10wt% and an effective pour point depressant for natural vegetable oils at 0.5-1wt%. **FUNCTIONAL PD-585** has the lowest shear stability index (best shear resistance) versus the other viscosity modifier options.

Biobased Viscosity Modifier, Typical Properties

Product	Viscosity, at 100°C	PSSI, ASTM D6278	PSSI, KRL	Chemistry	Base Oil	Thickening Efficiency, 10wt%, 40°C	Ecolabel LuSC?	NSF HX-1?
V-515	8000	50	N/A	Proprietary	Veg Oil	83.6 cSt	Yes	No
V-521	5000	30	N/A	Proprietary	Veg Oil	76.8 cSt	Yes	No
V-508	1250	29	N/A	Proprietary	Veg Oil	71.9 cSt	Yes	Yes
PD-585	1200	4	56	PMA	Ester	80.3 cSt	Yes	No

See the **Viscosity Modifiers** brochure from Functional Products Inc. for more information on viscosity modifier selection, handling, and blending.

Synthetic Base Stocks

Industrial gear oil and HVLP high VI hydraulic fluid require exceptional shear stability to remain in grade during severe duty service. Synthetic base stocks offer KRL shear stabilities of $\leq 15\%$. However, most synthetic base stocks are not biodegradable and require the use of low viscosity natural oils or synthetic esters to meet biodegradability claims.

Synthetic base stocks may be used with both a base oil and a viscosity modifier to increase shear stability while maintaining high viscosity index and excellent low temperature fluidity.

High Viscosity Synthetic Base Stocks, Typical Properties

Product	Viscosity, at 100°C	PSSI, ASTM D6278	PSSI, KRL	Chemistry	Base Oil	Thickening Efficiency, 10wt%, 40°C	Biodeg. OECD 301B	Ecolabel LuSC?
V-732	2000	0	15	EPO	None	87.6 cSt	0%	No
V-705	6500	0	4	Proprietary	None	115.5 cSt	0%	No

Biobased Base Stocks, Typical Properties

Product	Viscosity, at 40°C	Viscosity, at 100°C	Viscosity Index	Chemistry	Pour Point, ASTM D97	Biobased wt%	Biodeg. OEC 301B	Ecolabel LuSC?
V-5019	1900	160	200	Polymeric Ester	-24°C	60%	71%	Yes
V-5048	4800	310	210	Polymeric Ester	-15°C	75%	71%	Yes

Terms and abbreviations:

PSSI – “Permanent Shear Stability Index”, a measure of how mechanical shearing damages the polymer and reduces viscosity.

ASTM D6278 – Diesel injector or Kurt-Orbahn shear. Mild shearing comparable to engine oil conditions.

20 Hour KRL – CEC L-45-A-99 or “tapered roller bearing” test. Severe shearing comparable to gear oils.

Chemistry – Type of polymer based on the monomers used.

EPO – Ethylene propylene oligomers. Low molecular weight, liquid copolymers of ethylene and propylene.

PMA – Polymethacrylates. Copolymers of short and long methacrylic esters.

Base Oil – Type of diluent oil used to prepare solubilized viscosity modifiers in liquid form.

Thickening Efficiency – Viscosity at 40°C of canola oil with 10wt% (for liquids) of product.

Biobased Tackifiers

Tackifiers provide anti-fling and anti-mist performance to high speed lubricants like bar & chain oils or saws.

Product	Viscosity, at 100°C	Compatibility	Chemistry	Base Oil	String Length, Ductless Siphon	Biodeg. OECD 301B	Ecolabel LuSC?	NSF HX-1?
V-584	2500 at 40°C	Veg Oil, Esters	Proprietary	Veg Oil	10	>60%	Yes	Yes
V-572	7500	Veg Oil, Esters	Proprietary	Veg Oil	5	>60%	No	No
V-188P2	9250	PAO, Petro. Oil	OCP	PAO	20	>60%	Yes	Yes

FUNCTIONAL V-584 is the primary tackifier for veg oil and synthetic esters.

FUNCTIONAL V-572 is a concentrated tackifier for building tack and viscosity in biobased greases.

FUNCTIONAL V-188P2 tackifies biodegradable polyalphaolefins and other biodegradable hydrocarbons for environmentally acceptable lubricants and eco-friendly products.

See the **Tackifiers** brochure from Functional Products Inc. for more information on use and testing.

Biobased Pour Point Depressants

Pour point depressants (or “cold flow improvers”) are critical for improving the low temperature fluidity of fatty esters, especially natural triglycerides like vegetable oil which contain high amounts of waxy fatty acids.

FUNCTIONAL PD-5## series pour point depressants are engineered to target the long chain fatty acids that inhibit the low temperature fluidity of certain biobased esters. Different vegetable oils or fats will respond differently to PPDs depending on the composition of the oil.

Product	Viscosity, at 100°C	Chemistry	Use With	Ecolabel LuSC?	US EPA Cleangredients?	NSF HX-1?
PD-585	1200	PMA	Vegetable oils	Yes	Yes	No
PD-555C	300	PMA	Vegetable oils	No	No	No
PD-570	400 at 40°C	Proprietary	Vegetable oils, biodiesel	No	No	No
PD-571	1100 at 40°C	Proprietary	Vegetable oils, biodiesel	No	No	No

FUNCTIONAL PD-585 is a highly concentrated PMA pour point depressant which can also perform as a shear stable viscosity modifier. Listed on both European Ecolabel LuSC list and the US EPA Cleangredients program.

FUNCTIONAL PD-555C is the lowest viscosity, low treat PPD for biobased. This product performs well with blends of vegetable oil with white oil or Group III to improve oxidative stability while retaining biodegradability.

FUNCTIONAL PD-570 and **PD-571** are unique bio-derived pour point depressants which provide second and third supply chain options versus PMA PPDs. Both products are cold flow improvers for methyl esters and biodiesel.

Biobased Packages and Components

Functional Products Inc. specializes in developing additive packages to allow non-conventional lubricant formulations using unique base stocks to perform as well or better than standard petroleum products.

See the **Industrial Additives** brochure from Functional Products Inc. for more information on basic packages and components for lubricants.

Eco-Friendly Packages and Components

For Lower Impact on the Environment

“Eco-friendly” packages are available as a better, lower impact alternative to standard zinc or hazard labeled industrial packages for petroleum oil. These additives, as concentrates, may carry some hazard labeling.

Product	Treat Rate, wt%	Application	Ecolabel LuSC?	NSF HX-1?
BC-15	1.5%	Bar & chain oil package	No	No
CI-426	0.2 – 0.5%	Corrosion inhibitor, AW/EP	No	Yes
CI-426EP	1 – 2%	Corrosion inhibitor package with enhanced AW/EP	No	Yes
HF-580	1.5 – 2.5%	Antiwear HF package (variable treat)	No	No
RD-540	2.2%	Rock drill and air tool package (emulsifying)	No	No
RD-540CP	2.4%	Rock drill and air tool package (demulsifying); gear oil	No	No
SGP-567	1.5%	Saw guide oil (emulsifying), forestry package	No	No
WA-60SF	1.5%	Saw guide oil (demulsifying)	No	No

Environmentally Acceptable Lubricant (EAL) Packages and Components

For EAL Programs and Marine Lubricant (US VGP) Use

“Environmentally acceptable” packages are registered on the European Ecolabel Lubricant Substance Classification (LuSC) list. These products meet all hazard labeling, biodegradability, and bio-accumulative requirements.

Product	Treat Rate, wt%	Application	Ecolabel LuSC?	NSF HX-1?
DF-400	0.1 – 1%	Defoamer for PAO, petroleum	Yes	Yes
DF-500	0.1 – 1%	Defoamer for veg oil, fatty ester	Yes	No
DM-400	0.1 – 1%	Demulsifier	Yes	Yes
HF-595	2.2%	R&O, AW HF, HVI HF	Yes	No
SGP-563	1.5%	Bar & chain, saw guide oil	Yes	No

Guide to European Ecolabel Lubricants

Overview

Ecolabel is a European standard for sustainable and environmentally acceptable products. One category is Lubricants which makes the European Ecolabel program one of several environmentally acceptable lubricant (EAL) programs.

In the US, European Ecolabel qualifies as one of several programs recognized by the US Vessel General Permit 2013. Products which meet Ecolabel status are self-certified as US VGP.

Base oils and additives for Ecolabel lubricants are pre-approved on the Ecolabel Lubricant Substance Classification (LuSC) list for formulators to use. Each component on the LuSC list carries an EEL Rating for biodegradation and aquatic toxicity i.e. "100% A / 100% D".

The final formula and its components must meet:

- minimum wt% of components meeting certain biodegradability status (A, B, C, X)
- maximum wt% of components with aquatic toxicity hazards (D, E, F, G)
- minimum technical performance, based on the type of product (hydraulic, bar&chain, etc.)

The limits vary based on the product category (PLL, ALL, TLL) and if it is a grease.

Product Categories for Finished Lubricants or Greases

Product categories are defined by their likelihood of loss to the environment based on the use.

PLL = Partial Loss Lubricant	Open gear, stern tube, two-stroke, oils for temporary corrosion protection
ALL = Accidental Loss Lubricant	Hydraulic fluids, metalworking fluids, gear oils for closed gears
TLL = Total Loss Lubricant	Chainsaw oils, wire rope lubricants, concrete release agents

Minimum Required wt% of Biodegradable Components by Product Category

Biodegradation Rating	PLL Fluids	ALL Fluids	TLL Fluids	Any Grease	Description
A - 'Readily'	>75%	>90%	>95%	>80%	Readily biodegradable.; not bioaccumulative
B - 'Inherently'	≤ 25%	≤ 10%	≤ 5%	≤ 20%	Inherently biodegradable; not bioaccumulative
C - 'No'	≤ 20%	≤ 5%	≤ 5%	≤ 15%	Not biodegradable; not bioaccumulative
X - 'Bioaccumulative'	≤ 0.1%	≤ 0.1%	≤ 0.1%	≤ 0.1%	Not biodegradable; bioaccumulative

Maximum Allowed wt% of Aquatic Toxic Components by Product Category

Toxicity Rating	PLL Fluids	ALL Fluids	TLL Fluids	PLL Grease	ALL Grease	TLL Grease	Aquatic Toxicity Test Limit (mg/L)
D - 'Non-Toxic'	No limit	No limit	No limit	No limit	No limit	No limit	>100 for fish, invertebrate, and algae
E - 'Harmful'	≤ 10%	≤ 10%	≤ 2%	≤ 15%	≤ 20%	≤ 10%	10-100 acute, 1-10 chronic
F - 'Toxic'	≤ 0.6%	≤ 2.5%	≤ 4%	≤ 0.6%	≤ 1%	≤ 0.4%	1-10 acute, 0.1-1.0 chronic
G - 'Very Toxic'	≤ 0.1%	≤ 0.1%	≤ 0.1%	≤ 0.1%	≤ 0.1%	≤ 0.1%	<1 acute, <0.1 chronic; use M factor

Components are also limited on wt% usage based on their GHS hazard labeling. See the European Ecolabel's 'User Manual – Lubricants' document for all details on formulation guidelines.

Guide to Ecofriendly Base Oils

Which base fluid should a formulator use when formulating ecofriendly or EAL lubricants? The answer depends on the intended application, performance requirements, and operating conditions. The table below summarizes typical advantages and disadvantages to consider for certain base fluids:

Class	Base Fluid	ISO VG	Pour Points	Advantages	Disadvantages
TG – glycerides	Vegetable Oils	32	-12 to -36°C *		
ES – synthetic ester	Adipate Esters	10 to 32	-50 to -65°C		
	Polyol Esters	10 to 46	-40 to -70°C		
	Complex Esters	100 to 2200	-24 to -51°C		
	Estolides	22 to 680	-18 to -51°C *		
PR – PAO, related	Group III Paraffinic	22 to 68	-15 to -51°C *		
	White Oils	22 to 100	-15 to -48°C *		
	Conventional Polyalphaolefins (PAO)	10 to 68	-60 to -75°C		
	Biobased Polyalphaolefins	10 to 150	-27 to -57°C		
PG - PAGs	Polyalkylene Glycols (PAG)	10 to 2200	-36 to -65°C		

* = Certain PPDs will help improve pour point range to minimum values shown.

Legend:

Additive Compatibility 	Toxicity / Hazards For Some Viscosities 	Aromatic Carbon (Mineral Oils) 	Wide Variety of Options 	Renewable / Biobased 	Viscosity Range 	Elastomer/ Seal Swell
Biodegradability 	Cost 	Supply Chain / Number of Suppliers 	Oxidation / Thermo. Stability 	Low Temp. Fluidity 	Lubricity / Load Carrying 	Properties Conflict