FUNCTIONAL PRODUCTS INC.

Innovative Chemistry for Lubricants

Additives for Biobased Products

QMS Certified to ISO 9001:2008 (With Design) REACH and GHS Compliant

8282 Bavaria Road - Macedonia, Ohio - 44056

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Additives for Biobased Lubricants

FUNCTIONAL PRODUCTS INC.

Functional Products Inc. was founded in 1985. The Quality Management System is certified to ISO 9001:2008 (with design). Functional Products is committed to compliance with current REACH and CLP regulations, including the Globally Harmonized System (GHS) for classification and labeling standard.

Functional Products is an active member or participant in the following professional technical associations: **NLGI, ELGI, NLGI India, STLE, KSTLE, AOCS, NSF, UEIL and ILMA.**

Functional Products formulates and blends over 200 active products and also provides custom formulary capability for short and long-run needs.

Headquarters, general offices and manufacturing plant are located in Macedonia, Ohio. Sales offices and stocking points are located throughout the United States and Canada, as well as Latin America, Europe, Australia, India and Asia.

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.

Health and Safety:

The product descriptions here, in Technical Data Sheets (TDSs) and on product labels are not intended to take the place of a Safety Data Sheet (SDS).

A SDS is provided with each order or sample shipment of an order or a sample and can be downloaded from our website:

www. functionalproducts. com
Phone: 1-330-963-3060

Why Convert from Mineral to Biobased Fluids?

As environmental concerns are growing, vegetable oils are finding their way into total-loss lubricants for military applications and outdoor activities such as forestry, mining, railroads, dredging, fishing and agricultural hydraulic systems. Lubricants based on vegetable oils offer significant environmental benefits as well as providing satisfactory performance in a wide array of applications. Government initiatives and advances in biobased lubricant technology are expanding the market for environmentally friendly products.

Hydraulic equipment can experience a hose rupture or fitting leak, releasing oil into the environment. It has been estimated that a hydraulic system can lose as much as three times its sump volume each year.

Shortcomings of vegetable oils, such as low thermo-oxidative stability and poor cold flow behavior may be improved through the use of additives that enhance oxidative stability, improve low temperature properties (pour points) and confer better wear properties.

FUNCTIONAL PRODUCTS' additives in this catalog improve the performance of commercially available biobased industrial oils such as hydraulic fluids, biodegradable oils for heavy equipment, biobased drip fluid for agricultural equipment including mineral oil-based lubricants for high-temperature applications.

Converting Machinery to Biobased Lubricants

When switching from a mineral oil-based rock drill, bar and chain, gear oil or hydraulic fluid to a biobased system, certain care should be exercised:

- Warm up the machinery to reduce the viscosity.
- Flush the sump and/or system with vegetable oil, circulate and drain.
- Fill with biobased fluids.
- Note the clarity and color of the oil.
- Inspect the machinery fluids frequently in order to learn how the fluid behaves.

Spent fluids may be recycled with filtration and in some cases may be revived with booster additives.

Compatibility

All **FUNCTIONAL PRODUCTS'** biobased additives are compatible with vegetable oils. Most additives are also compatible with some synthetic esters. See the Technical Data Sheets for specific information regarding ester compatibility.

Definitions

Biobased — According to the Office of the Federal Environmental Executive, biobased products are commercial or industrial products (other than food or feed) that are composed in whole or in significant part of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials. In the past, The United States Department of Agriculture (USDA) generally described biobased in reference to products, including lubricants and greases, that were made of at least 51% biological materials.

Thickeners for Biobased Lubricants

Triglyceride oils are preferred as base stocks for blending hydraulic gear oils, rock drill oils and lubricants intended for use in environmentally sensitive applications. A drawback is the low viscosity of 40 cSt at 40°C. A thickener may be used to provide higher viscosity, and a tackifier may be used to provide tack to the finished product.

FUNCTIONAL V-508, 508M and **V-515** are thickeners for vegetable or animal-based oils to blend lubricants of ISO 46, ISO 68 or ISO 100 viscosity grades. **FUNCTIONAL V-516** is a thickener for high oleic vegetable oils used to blend lubricants of ISO 46, ISO 68 or ISO 100 viscosity grades. These thickeners are ideal for use with synthetic esters. **FUNCTIONAL V-508** and **V-508M** are best for use with dioctyl adipate, ditridecyl adipate, C_6, C_7, C_8 polyol esters, trimethylolpropane tricaprylate and trioctyl trimellitate. **FUNCTIONAL V-515** and **V-516** are best with triisodecyl trimellitate and diisodecyl phthalate.

FUNCTIONAL V-508F is a thickener for vegetable or animal-based fatty oils, used to blend lubricants of ISO 46 or ISO 68 viscosity grades. **V-508F** has excellent high-temperature properties, is shear stable, and has a PSSI of 28%. With approximately 70% biodegradable content, **V-508F** is biodegradable under all widely used standards.

Typical Properties

	V-508F	V-515	V-516
Compatibility	High-oleic canola oil, esters, dioctyl adipate, trimethylpropane trioleate		
Specific Gravity	0.93	0.93	0.91
Lbs. per Gallon	7.75	7.75	7.60
Flash Point	150°C (300°F)	150°C (300°F)	>260°C (500°F)
Kinematic Viscosity @ 100°C	7000 cSt	8000 cSt	5500 cSt
Color (ASTM D1500)	Yellow (<4)	Yellow (<4)	Yellow (<2)

Treatment Levels in High-oleic Canola

Typical / High Shear Service	ISO 46	ISO 68	ISO 100
V-508F	2.0%—2.5%	4.5%—5.0%	8.0%—9.0%
V-508M	3.0%—3.5%	7.0%—7.5%	13%—14%
V-515	2.0%—2.5%	6.0%—7.0%	15%—16%
V-516	1.5%—2.0%	5.0%—6.0%	12%—15%

Warming **FUNCTIONAL PRODUCTS'** biobased additives to 65°C (150°F) may facilitate pumping and handling. Extended storage at elevated temperatures is not recommended for any product derived from vegetable oils. Safe handling precautions are the same as those to be used with vegetable oils; see the current Safety Data Sheet for details.

Low Temperature Performance of Thickeners for Biobased Lubricants

Pour points were determined for solutions of **FUNCTIONAL V-508F** and **V-515** in high-oleic canola oil (H-OC), dioctyl adipate (DOA) and trimethylpropane trioleate (TMPTO).

	V-508F			V-515		
	H-OC	DOA	TMPTO	H-OC	DOA	TMPTO
			Performance without PD-555C			
Haze Onset (°C)	-12	-12	-15	-12	-25	-18
Pour Point (°C)	-15	-9	-12	-19	<-50	-19
			Performance with PD-555C			
Haze Onset (°C)	-22	-12	-18	-22	—	-22
Pour Point (°C)	-25	-15	-22	-25	—	-34

Solutions in H-OC and DOA were prepared to be ISO 46, while TMPTO solutions were prepared to be ISO 68 (TMPTO is ISO 46 without additives).

Cold Flow Improvers for Vegetable Oil Based Lubricants

FUNCTIONAL PD-551, PD-555C and **PD-557** modify wax crystal formation in biobased lubricants. Their primary use is to improve the cold flow properties of biobased lubricants at temperatures below the cloud point. These products are effective under both rapid-cooling and extended cold-storage conditions. Cold flow improvers are effective in hydraulic fluids, chain saw oils, pneumatic tool lubricants and other lubricants made from canola oil, sunflower oil or other triglycerides. The low viscosity of **PD-555C** makes it very easy to handle. **FUNCTIONAL PD-580** meets the EPA Design for the Environment specifications.

Typical Properties

	PD-551	PD-555C	PD-580
Composition	Proprietary Copolymer	Proprietary Copolymer	Proprietary Copolymer
Diluent	Vegetable Oil	N/A	Vegetable Oil
Appearance	Light-colored Liquid	Light-colored Liquid	Light-colored Liquid
Odor	Mild	Mild	Mild
Specific Gravity	0.93	0.93	0.93
Lbs. per Gallon	7.75	7.75	7.75
Flash Point	>160°C (320°F)	>160°C (320°F)	>160°C (320°F)
Kinematic Viscosity	200 cSt at 100°C 1200 cSt at 40°C	300 cSt at 100°C —	300 cSt at 100°C —

To reduce the pour point of canola or other low-saturate triglyceride oils to below -23°C (-10°F), a treatment of 0.3% to 0.5% is usually sufficient. To reduce the pour point to below -29°C (-20°F), a treatment of 0.5% to 1.0% is usually sufficient. For stability in extended storage at -23°C (-10°F), a treatment level of 1.0-2.5% is usually necessary. Since the responsiveness of triglyceride to wax-crystal modifiers is extremely variable and may be dependent on the cooling history, the user should determine the appropriate treatment level.

Tackifiers for Biobased Lubricants and Esters

Biobased tackifiers are additives that confer tack or stringiness to lubricants made from vegetable or animal based fatty oils. They are principally used to provide adherence in chain oils, saw guide oils, down hole drilling oils, open gear oils or oils used to lubricate in baking or food processing facilities. They may also be used to inhibit stray mists or to provide drip resistance in other products. They may also be used to provide thickening and tack in oils that contain high levels of fatty additives, such as cutting oils.

NSF

Nonfoods Compounds Program Listed

FUNCTIONAL V-584 has been approved by the NSF as an additive for lubricants with incidental food contact (#120913, category HX-1, HX-2). It is principally used to provide adherence in chain oils in environmentally sensitive or food-processing locations. It will also inhibit stray mists and provide drip resistance. For tackifying vegetable oil based single use lubricants, **FUNCTIONAL V-584** may be used at lower treatment level.

FUNCTIONAL V-592 is recommended for use with synthetic esters and blown or polymerized vegetable oils that can be difficult to additize. A unique blend of synergistic polymers, **V-592** imparts tackiness and adhesion to synthetic esters.

Typical Properties

	V-515	V-584	V-592
Composition	Polymer	Polymer	Polymer
Compatibility	Vegetable Oil	Vegetable Oil	Vegetable Oil, Blown Vegetable Oil, Synthetic Esters
Lbs per Gallon	7.75	7.75	7.95
Flash Point	150˚C (300˚F)	150˚C (300˚F)	150˚C (300˚F)
Kinematic Viscosity	8000 cSt at 100˚C	2500 cSt at 40˚C	900 cSt at 100˚C
Thickening Efficiency (10% in Canola Oil)	75 cSt at 40˚C	60 cSt at 40˚C	70 cSt at 40˚C
Color (ASTM D1500)	Yellow-orange (<4)	Hazy Yellow-orange (<3)	Light Yellow (<1)

A treatment level as low as 1% will provide tackiness in a vegetable oil. The typical treatment level for a chain lube is 3-7%; about 5% will bring a vegetable oil to ISO 46 and 10% to ISO 68. Due to its high viscosity index, a fatty-oil derived ISO 46 product may actually have a higher viscosity at 100°C than many ISO 100 mineral based products. The slight residual haze in these higher viscosity blends does not affect performance. A treat level of between 0.2% and 1.0% of **FUNCTIONAL PD-551** or **PD-555C** can inhibit the freezing of the base oil, extending the usable temperature range of the lubricant. Minimization of hydrocarbon aerosol escape from mist lubricated and pneumatic equipment requires about 1%. Since there are no standardized test methods for tackiness or stray-mist inhibition, the appropriate treatment level is best determined by the user.

While warming **FUNCTIONAL V-515** to about 65°C (150°F) or **FUNCTIONAL V-584** to about 50°C (120°F) may facilitate pumping and handling, extended storage of these or any other vegetable oil derived products at elevated temperatures is not recommended. For best tackiness retention, do not warm above about 65°C (150°F).

Safe handling precautions are the same as those to be taken with vegetable oils; see the current Safety Data Sheet. **FUNCTIONAL V-584** and **V-515** have a shelf life of 6 months. Avoid mechanical shearing during handling and blending to minimize possible loss of tackiness.

Additives for Biobased Hydraulic Fluids

FUNCTIONAL HF-546 is an additive package for producing ISO 46 hydraulic fluids. It is formulated to provide excellent antiwear and corrosion resistance, oxidative stability, foam resistance, cold flow properties and resistance to water. **HF-546, HF-560** and **HF-580** are compatible with TMP trioleate diluents for increased thermal and oxidative stability.

FUNCTIONAL HF-560 is an additive package for producing Military Specification MIL-PRF-32073 type hydraulic fluids based on biodegradable esters or vegetable oils. **FUNCTIONAL HF-560** provides oxidation and corrosion protection, extreme-pressure/antiwear activity, and resistance to water and foaming. Refined vegetable oils are recommended to pass the military oxidation requirement. To improve the oxidative stability of the vegetable oil, **FUNCTIONAL AO-550** may be used at 2.2% treat.

Specifications of Finished Hydraulic Fluid to Meet MIL-PRF-32073

Formula		Tests Passed	
High-oleic Canola Oil	95.65%	Maximum Pour Point	Four Ball Test (10 & 40 kg load)
Functional HF-560	1.85%	Oxidation Stability (PDSC)	Biodegradability
Functional V-516	1.5%	Swelling of Synthetic Rubber	Foaming Sequences 1, 2 and 3
Functional PD-551	1.0%	Evaporation Loss	1 Year Storage Stability @ 24°C

FUNCTIONAL HF-580 is a non-hazardous light color, low odor additive package which is compatible in a wide variety of base oils including vegetable oils, high oleic algal oils, modified castor oils and synthetic esters including TMP and pentaerythritol esters. It also has outstanding solubility in Groups III and IV oils (PAOs) as well as OSP fluids. **HF-580** can be formulated in high oleic canola oil to ISO 46 grade using approximately 2.5% **FUNCTIONAL PD-551** as a highly shear stable thickener. The ISO 46 grade passes the V104C Vane Pump Test (ASTM D7043) and exhibits excellent demulsibility, rust and copper inhibition, 4-ball wear performance and hydrolytic and thermal stability. **FUNCTIONAL HF-580** shows exceptional RPVOT oxidative stability, especially when used in base fluids with high oleic, high saturate and low polyunsaturate content such as very high oleic algal oils, modified castor oils and OSPs.

Typical Properties

	HF-546	HF-560	HF-580
Appearance	Hazy Light Green Liquid	Hazy Amber Liquid	Clear Amber Liquid
Odor	Mild	Mild	Mild
Specific Gravity	0.92	0.96	0.98
Lbs per Gallon	7.7	8.0	8.2
Flash Point	>150°C (300°F)	112°C (234°F)	> 230°C (450°F)
Kinematic Viscosity	80.0 cSt at 100°C 684 cSt at 40°C	7.0 cSt at 100°C 131 cSt at 40°C	— 50 cSt at 40°C
Treatment Level (by weight)	4.4%	1.85%	2.5%

The service life of the hydraulic fluid is limited by the stability of the vegetable oil; a maximum temperature of 70°C (160°F) is recommended. Heating before blending is not required.

Open Gear Oil Additive Package

FUNCTIONAL GA-502 is an EP additive designed for use in biobased open gear lubricants. **FUNCTIONAL GA-502** contains antiwear additives, demulsifiers, a pour point depressant and a tackifier. Fluids containing **FUNCTIONAL GA-502** are suitable for use in environmentally sensitive areas. The typical treat level is 2–3% in a suitable base stock.

Multifunctional Rock Drill Package

FUNCTIONAL RD-535 is a high performance oil additive package having EP/antiwear, corrosion inhibition and tackiness properties especially suited for rock drilling applications. **FUNCTIONAL RD-535** is readily biodegradable when formulated with vegetable base stocks and is designed to meet the requirements of pneumatic tools, down-hole and surface drilling equipment. It is formulated with a tackifier to allow the lubricant to adhere to tooling surfaces, further reducing corrosion and wear in the presence of compressed air. It is designed to emulsify water in wet conditions. The wear reduction performance greatly reduces the incidence of premature bit shanking and reduces operating costs.

FUNCTIONAL RD-535 is a proprietary formulation recommended for vegetable oil base stocks. **FUNCTIONAL RD-535** is soluble in oil, insoluble in water, and contains 20% sulfur and 0.9% phosphorous by weight. See the Technical Data Sheet for additional information. The recommended initial treat level is 5% **FUNCTIONAL RD-535** by weight. The optimum level is dependent on the severity of the application. At 5% by weight in canola oil, the viscosity is 8.6 cSt at 100°C, 33.8 cSt at 40°C and the VI is 249. **FUNCTIONAL RD-535CP** is a similar product that demulsifies water.

FUNCTIONAL RD-535 may be a skin and eye irritant, and should be handled with suitable personal protection. The maximum heating temperature is 140°F. At higher temperatures, **FUNCTIONAL RD-535** may be a respiratory irritant.

Finished ISO 220 Rock Drill Oil Performance

Formula	
(by weight in high oleic canola oil)	
FUNCTIONAL RD-535	5%
FUNCTIONAL V-508F	
For ISO 220	15%
For ISO 320	18%
For ISO 460	20%

Typical Properties	
Flash Point (COC)	>150°C
Kinematic Viscosity at 100°C (ASTM D445)	36 cSt
Kinematic Viscosity at 40°C (ASTM D445)	224 cSt
Viscosity Index	211
Performance	
4-Ball EP Test (ASTM D1783), weld load	250 kg
Timken Load Test (ASTM D1782), failure point	>70 lbs. (31 kg)
Emulsion Stability (ASTM D1401)	1/6/73 (30 min)

Anti-oxidant for Biobased Lubricants

Vegetable oils generally have poor oxidative stability that may contribute to oil failure due to the rapid increase in viscosity, and sludge and deposit contamination. BHT or TBHQ may be used as an economic anti-oxidant for vegetable oils at treat rates as low as 0.15% by weight.

For premium performance, **FUNCTIONAL AO-550** is recommended. **AO-550** is a proprietary mixture of oxidation inhibitors, anti-wear agents and rust inhibitors designed to give optimum performance in ashless bar and chain oils, hydraulic fluids, industrial gear oils or whenever enhanced oxidative stability is required of a vegetable or mineral oil.

AO-550 Performance in Canola Oil

	Untreated Canola Oil	With 1% AO-550
RPVOT	36 minutes	195 minutes
AOCS Cd 12b	4 hours	590 hours

Purchasing Information

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