FUNCTIONAL PRODUCTS INC.

Innovative Chemistry for Lubricants

Grease Additives

QMS Certified to ISO 9001:2015 (With Design) REACH and GHS Compliant

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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**

Grease Additives

Grease polymers are used to enhance the physical properties of grease by reinforcing the network of thickener molecules that bind the grease together.

The right grease polymer in a grease can produce a range of benefits including:

Greater Adhesion
Reduced Bleeding
Elevated Tackiness
Added Yield
Superior Shear Resistance
Enhanced Water Resistance

In addition, there are various additives and packages which are best suited to the unique composition and structure of grease rather than fluid lubricants. All relevant products are compiled here for ease of use by grease formulators.

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)

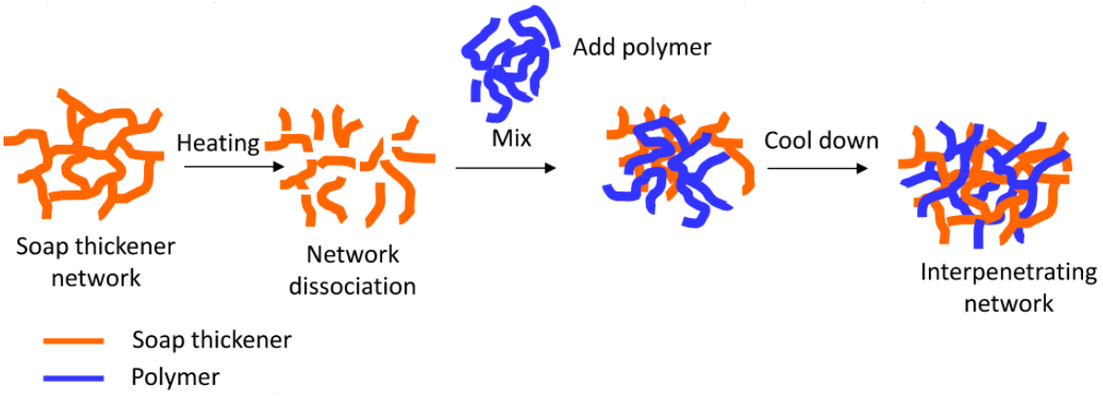
Functional Products Inc. was noted as an 'HPM Valuable Contributor' for the NLGI High Performance Multiuse Grease Specification (2020).

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).

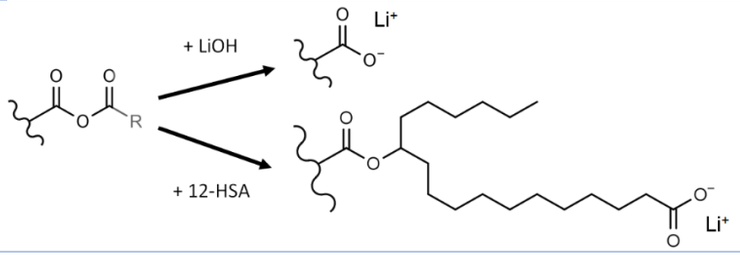
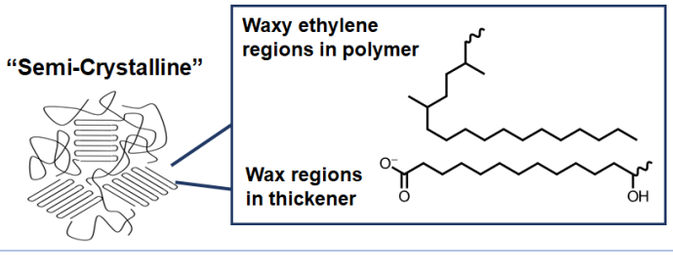
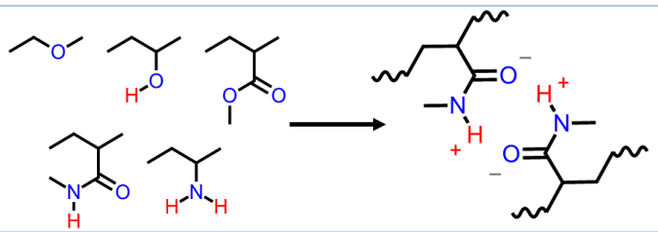
Introduction to Grease Polymers

Grease polymers are high molecular weight, often functionalized, polymers which reinforce the internal structure of grease to provide enhanced adhesion and cohesion. Grease and polymer additive are like concrete and rebar – both structures complement one another when assembled correctly.

When grease polymer is added (see last page for How/When to Add Grease Polymer), the polymer network and grease thickener network form an interpenetrating network or "IPN".



Three key types of grease polymers are used to modify different greases are:

Reactive	Reactive anhydride groups on the polymer can reactive with free metal ions like a diacid; or with free hydroxyl groups like a boron complex	
Temperature Sensitive	Waxy regions of high ethylene polymers can co-crystallize and lock together with waxes in the thickener molecular	
Hydrogen Bonding	Polar oxygen or nitrogen groups form strong acid-base associations between polymer and the thickener	

Basic Grease Polymers

Formulators should try two or three different grease polymer types to establish which type works best with the formulator's grease composition and production method. The basic grease polymer options are readily available and efficient in modifying most greases.

The key products to try first in a new grease formulating project are:

Product	Suggested wt%	Form	Polymer Type	Recommended Use
V-4020	0.25wt%	Pellet	Reactive	Lithium, lithium complex, aluminum complex
V-207	0.5wt%	Flake	Temp. Sensitive	Calcium sulfonate, calcium sulfonate complex
V-191	0.5wt%	Liquid	Hydrogen Bonding	Particle (clay, silica)

Treat rate can have a strong influence on the performance of grease polymers. Test three different treat rates – the suggested wt%, 2x the suggested wt%, and 0.5x the suggested wt%.

Advanced Grease Polymers

Advanced grease polymers are more specialized derivatives of the basic grease polymers. If performance with a basic grease polymer is improved but still not on target, then try an advanced grease polymer of the same type.

Reactive Type Polymers

For Lithium, Lithium Complex, and Aluminum Complex Greases

Product	Suggested wt%	Form or Viscosity, 100°C	Polymer Type	Application Note
V-4004A	4wt%	Liquid, 650 cSt	Reactive	Liquid equivalent to V-4020 for rapid incorporation to grease
V-4700	5wt%	Liquid, 10000 cSt	Reactive	Enhances water resistance in high viscosity PAO or PB
V-4040P	0.25wt%	Flake	Reactive	Colorless, flake form alternative to V-4020; faster addition
V-4010	0.25wt%	Pellet	Reactive	Specialized for water washout; requires high temperature

FUNCTIONAL V-4004A offers a convenient liquid alternative to the **FUNCTIONAL V-4020** pellet if faster incorporation is required in heavier base stocks or when using faster kettle technology (pressure kettle, contactor).

FUNCTIONAL V-4700 is a specialized grease polymer for improving the water resistance properties of high viscosity PAO/mPAO base stocks. These high viscosity base stocks tend to be difficult to dissolve polymer in and most grease polymers do not function correctly. **FUNCTIONAL V-4700** performs as needed in these low solvency, high viscosity blends to improve water sprayoff and water washout.

FUNCTIONAL V-4040P is a flaked, solid alternative to **FUNCTIONAL V-4020** which offers lower color, faster dissolving time, and improved yield in the finished grease.

FUNCTIONAL V-4010 is a reactive pellet which has been tuned specifically to improve water washout. Other grease polymers tend to improve water sprayoff. **FUNCTIONAL V-4010** requires high (150°C) temperatures to dissolve.

NSF HX-1 Temperature Sensitive Polymers

For H1 Calcium Sulfonate, Calcium Sulfonate Complex, and Aluminum Complex Greases

Product	Suggested wt%	Form	Polymer Type	Recommended Use
V-211	0.5wt%	Flake	Temp. Sensitive	Industrial; aluminum complex; polyurea
V-4064	2wt%	Pellet	Temp. Sensitive	H1 greases with full PAO or mPAO base fluid

FUNCTIONAL V-211 is styrene grease polymer which further enhances performance over **FUNCTIONAL V-207** for even higher water resistance and mechanical stability. Performs well in both industrial (Group I/II) and NSF H1 (white oil, Group III) based greases. Avoid naphthenic oil or naphthenic/paraffinic oil blends as they may negatively affect texture.

FUNCTIONAL V-4064 is a best suited for improving low solvency PAO grease for NSF H1 applications. **FUNCTIONAL V-4064** has lower solubility and can be a good candidate to replace **FUNCTIONAL V-207** in high solvency naphthenic greases.

Hydrogen Bonding Polymers

For Inorganic Particle Greases and Ester/PAG/Biobased Grease

Product	Suggested wt%	Form or Viscosity, 100°C	Polymer Type	Application Note
V-191M	0.5%	Emulsion	Hydrogen Bonding	V-191 with improved storage stability
V-508M	10%	2500	Hydrogen Bonding	Builds toughness and water resistance in ester/PAG
V-572	10%	7500	Hydrogen Bonding	Best used as a tackifier in ester based greases

FUNCTIONAL V-191M is a modified version of **FUNCTIONAL V-191** which has greater storage stability when reusing a single pail or drum for multiple batches over a period of time.

FUNCTIONAL V-508M and **V-572** are high molecular weight biobased viscosity modifiers which provide tack and toughness to high solvency greases using vegetable oil, synthetic ester, or PAG base oils; or greases using polar particles like clay and silica. See the **Biobased Additives** brochure from Functional Products Inc. for more options.

Full Synthetic Grease Polymers

For Mineral Oil-Free and High Performance Grease Formulas

Product	Suggested wt%	Form or Viscosity, 100°C	Polymer Type	Recommended Use
V-188P2	1.5wt%	Liquid, 9250 cSt	Temp. Sensitive	Shear stable and heat resistant OCP tackifier in PAO
V-4004P2	5wt%	Liquid, 125 cSt	Reactive	Liquid reactive grease polymer in PAO

FUNCTIONAL V-188P2 is a PAO-based version of the shear stable and heat resistant **FUNCTIONAL V-188** olefin copolymer tackifier. This is the best option for simply adding long lasting tackiness to a synthetic grease.

FUNCTIONAL V-4004P2 is a PAO-based version of **FUNCTIONAL V-4004A** liquid reactive grease polymer.

Additives and Packages

The structure and high solids content of grease can favor different additive chemistries than typically used in fluid lubricants. These additives and packages have been successful in improving the wear, extreme pressure, and corrosion resistance properties of industrial and specialty grease.

Product	Suggested wt%	Form	Role	Recommended Use	NSF H1? and wt%
GA-614	3wt%	Liquid	Gear Oil Package	Ashless sulfur-phosphorus industrial package	No
GA-400	1.1wt%	Liquid	Gear Oil Package (HX-1)	Ashless HX-1 gear oil package	Yes, 1.1%
CI-426	0.5wt%	Liquid	Corrosion, Antiwear	Improves rust resistance	Yes, 0.5%
CI-426EP	2wt%	Liquid	Corrosion, Antiwear, EP	Top treat for addition wear and EP protection	Yes, 2%
CERAMAX	1wt%	Powder	Extreme pressure (EP)	Micronized boron nitride; high temp. solid lube	Yes, 40%

See the **Industrial Additives** brochure from Functional Products Inc. for more details and options.

Tackifiers for Grease

Lube oil tackifiers are highly effective at adding tackiness to grease without affecting other properties. Greases respond best to the concentrated, high active content tackifiers listed below.

These high molecular weight polymers are sensitive to severe milling and homogenizing of grease. If milling results in significant tack loss then use the more shear stable **FUNCTIONAL V-188** or a solid grease polymer **FUNCTIONAL V-207** to add tackiness which will resist the milling process.

Product	Suggested wt%	Form or Viscosity, 100°C	Description	Specialty Whitelist?
V-176	1.0%	Liquid, 2900 cSt	Versatile industrial PIB tackifier, excellent handling	No
V-177	0.5%	Liquid, 10500 cSt	Concentrated, high viscosity PIB tackifier	No
V-188	1.5%	Liquid, 4000 cSt	Shear stable and heat resistant OCP tackifier	No
V-422	1.0%	Liquid, 3000 cSt	NSF HX-1 food grade PIB tackifier	NSF HX-1
V-425	1.5%	Liquid, 3000 cSt	NSF HX-1 food grade OCP tackifier	NSF HX-1

See the **Tackifiers** and **Food Grade** brochures from Functional Products Inc. for more details and options.

Viscosity Modifiers for Grease

Viscosity modifiers (VMs) are high performance alternatives to heavy petroleum oils to improve the low temperature and high temperature viscosity characteristics of the base oil. VMs can also be cost effective or readily available alternatives to bright stock when supply becomes difficult.

See the **Viscosity Modifiers** brochure from Functional Products Inc. for more details and options.

Product	Chemistry	Viscosity, at 100°C	SSI, D6278	SSI, 20 Hr KRL	Key Applications / Notes
V-731	EPO	1100	0	15	Ethylene-propylene oligomer, synthetic base stock
V-732	EPO	2000	0	15	Ethylene-propylene oligomer, synthetic base stock
V-4055	OCP	950	25	80+	VM for high viscosity and good low temperature
V-158F	OCP	1600	50	80+	VM for high cohesion and physical resistance
V-711	Styrene	Flake	7	71	Styrene olefin copolymer flake, low MW
V-4316	Styrene	3500	60	80+	Styrene olefin copolymer liquid, high MW

'Ethylene propylene oligomers' (EPO) are pure, free-flowing liquid copolymers of ethylene and propylene. These materials combine the best properties of PIB thickeners and mPAO: very high thickening efficiency, excellent shear stability, and very low volatility for high performance applications like bearing grease or open gear lubricants. **FUNCTIONAL V-731** and **V-732** are 1100 and 2000 cSt at 100°C, respectively.

Olefin copolymers (OCP) are typically high molecular copolymers of ethylene and olefins like propylene. These materials are diluted in base oil to prepare convenient and economic liquid additives. **FUNCTIONAL V-4055** is a high viscosity, medium molecular weight OCP with higher propylene which offers high viscosity but excellent low temperature mobility as an mPAO replacement. **FUNCTIONAL V-158F** is a high molecular weight olefin copolymer with higher ethylene which provides viscosity, tack, oil bleed reduction, and water resistance.

Styrene copolymers offer the additional benefit of improved water resistance and hydrophobicity. Styrene copolymers are effective in polyurea to control oil bleed and compatibilize the thickener due to the inclusion of aromatic isocyanates in the polyurea thickener. **FUNCTIONAL V-711** and **V-4316** are styrene olefin copolymer viscosity modifiers. **FUNCTIONAL V-711** is a 7 SSI flake form polymer used in lubricants and **FUNCTIONAL V-4316** is a high SSI variant that favors grease.

How/When to Add Grease Polymers

Always confirm times and temperatures on the lab scale (< 50 pounds / 25 kilograms) before scaling to production.

If using an open kettle design which will take multiple hours for saponification and cooling:

Grease Polymer Type	Form	When/How
Temperature Sensitive + Viscosity Modifiers	Solid	With cooling oil, Mix 1-3 hours @ 80-100°C / 176-212°F
	Liquid	With cooling oil, Mix 1 hour @ 80-100°C / 176-212°F
Reactive	Liquid	
Hydrogen Bonding	Solid or Liquid	With cooling oil, Mix 1-3 hours @ 100-120°C / 212-248°F
Temperature Sensitive with High Melt Point (Styrene OCP, Semi-Crystalline OCP)	Solid	
Reactive	Solid	Add before reaction – after the initial charge of base and acid
Lube Oil Tackifiers	Liquid	Add at end with additives, packages

If using a fast kettle or reaction process:

Reactor Type	Recommendation
Pressure Vessel – High Temperature (>150°C)	Reactive grease polymers – charge polymer to kettle along with oil/thickener before reaction. Non-reactive grease polymers – avoid high temperature for long times. Add in liquid form to finishing kettle.
Pressure Vessel – Medium Temperature (<150°C)	Charge solid polymer to kettle along with oil/thickener before reaction.
Contactor Vessel	Use liquids to avoid undissolved solid buildup; or add in finishing kettle.
Continuous Process	Use pre-diluted liquid additives to allow mixing (no agitation).