

Grease 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

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)

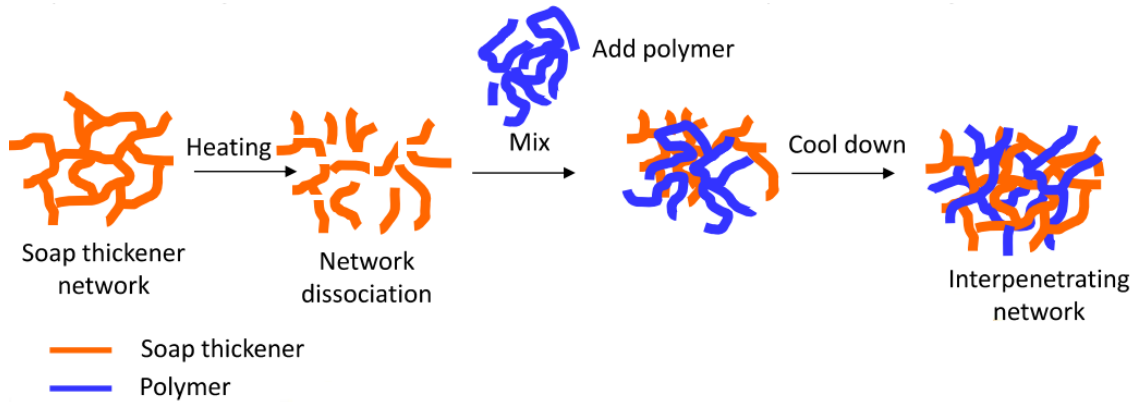
Functional Products Inc. was noted as an 'HPM Valuable Contributor' for the NLGI High Performance Multiuse Grease Specification (2020).

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

The diagram shows a chemical reaction where a reactive anhydride group (represented by a wavy line and a carbonyl group) reacts with LiOH and 12-HSA (12-hydroxystearic acid). The reaction produces a lithium salt (represented by a wavy line and a carboxylate group with Li^+) and a long-chain ester (represented by a wavy line and a long alkyl chain with a terminal carboxylate group and Li^+).

Temperature Sensitive

Waxy regions of high ethylene polymers can co-crystallize and lock together with waxes in the thickener molecular

The diagram illustrates the concept of "Semi-Crystalline" regions. It shows a polymer chain with waxy ethylene regions (represented by a wavy line and a long alkyl chain) and wax regions in the thickener molecule (represented by a long alkyl chain with a terminal hydroxyl group). The diagram shows how these regions can co-crystallize and lock together.

Hydrogen Bonding

Polar oxygen or nitrogen groups form strong acid-base associations between polymer and the thickener

The diagram shows a chemical reaction where a polymer chain with polar oxygen or nitrogen groups (represented by a wavy line and a carbonyl group) forms strong acid-base associations with a thickener molecule (represented by a long alkyl chain with a terminal hydroxyl group). The reaction shows the formation of a hydrogen bond between the oxygen and hydrogen atoms, resulting in a complex structure.

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-4033 | 1.5wt% | Liquid, 3500 cSt | Reactive | Extra concentrated V-4004A |
| 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 and **V-4033** offer 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-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 olefin copolymer which further enhances performance over **FUNCTIONAL V-207** for extreme water resistance. 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. This styrene copolymer is also effective (along with styrene viscosity modifiers) in polyurea greases due to the aromatic isocyanates used.

FUNCTIONAL V-4064 is a best suited for improving low solvency PAO grease for NSF H1 applications. **FUNCTIONAL V-4064** has improved thermal and oxidative stability versus **FUNCTIONAL V-207** or **FUNCTIONAL V-211**.

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-508F | 5% | 7000 | Hydrogen Bonding | Builds toughness and water resistance in ester/PAG |
| V-572 | 5% | 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-508F 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-4700 | 5wt% | Liquid, 10000 cSt | Reactive | Enhances water resistance in high viscosity PAO or PB |
| 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-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-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 | Viscosity, at 100°C | SSI, ASTM D6278 | SSI, 20 Hour KRL | Key Applications / Notes |
|---------|------------------------|--------------------|---------------------|---|
| V-731 | 1100 | 0 | 15 | Ethylene-propylene oligomer, synthetic base stock |
| V-732 | 2000 | 0 | 15 | Ethylene-propylene oligomer, synthetic base stock |
| V-711 | Flake | 7 | 71 | Styrene olefin copolymer flake, low MW – used in polyurea |
| V-4055 | 950 | 25 | >80 | mPAO replacement |
| V-158F | 1600 | 50 | >80 | Effective viscosity modifier for grease |
| V-4316 | 3500 | 60 | >80 | Styrene olefin copolymer liquid, high MW – used in polyurea |

FUNCTIONAL V-731 and **V-732** are 1100 and 2000 cSt ethylene-propylene oligomer. EPOs offer very high thickening efficiency and shear stabilities for high performance applications like bearing grease or open gear lubricants.

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 specifically for modifying grease. 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. Use **FUNCTIONAL V-211** for NSF HX-1 greases.

FUNCTIONAL V-158F is a high molecular weight olefin copolymer in light oil which provides viscosity, tack, oil bleed reduction, and water resistance.

FUNCTIONAL V-4055 is a high viscosity polyolefin viscosity modifier which is used to replace mPAO base stocks to improve low temperature fluidity, additive compatibility, and economics. Treat as an “mPAO 1000”.

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 | @ 80-100°C / 176-212°F |
| 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. |
| Contacting 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). |