Fluoroguard™
Polymer Additive

General Overview

Fluoroguard™ is a range of colorless, odorless, and chemically inert polymer additives based on fluorinated synthetic oil. Fluoroguard™ is designed for a variety of uses—in gears, bushings, automotive weather stripping and interiors, footwear, O-rings, seals, polymer films, and even to improve processing of snowboards.

Chemours™

Introduction

Fluoroguard™ products from Chemours are multifunctional polymer additives based on fluorinated synthetic oil. They are perfluoropolyether (PFPE) and have excellent color, UV, and thermal stability. Added to plastics and elastomers, they improve processing of polymers. Fluoroguard™ internally lubricates to improve flow properties, processibility, throughput, uniform mixing/dispersion of ingredients, and offers many advantages over competitive process aids.

This patented technology improves properties of both thermoplastic and thermoset polymers by increasing wear and flex fatigue resistance and making parts last longer. In addition, Fluoroguard™ eliminates marring and scratching of polymer surfaces, such as styrene ethylene butylene styrene (SEBS) and thermoplastic polyurethane (TPU). Fluoroguard™ also offers other benefits, such as improved physical properties, product gloss, surface lubricity, and reduced coefficient of friction (COF) and squeak/noise.

In some applications, Fluoroguard™ is compliant with the USP Plastics Class VI requirements and European Blue Angel standards.

Fluoroguard™ can be used in a variety of thermoplastic and thermosetting polymers at typically less than 1% (by weight) to improve mechanical performance of products and processing characteristics.

Product Form and Grades

Fluoroguard™ is a liquid additive and packaged in 1-gal plastic bottles and 5-gal pails. Custom masterbatches of Fluoroguard™ can also be obtained through licensed compounders.

Three grades of Fluoroguard™—PCA, SG, and PRO—are available for different application areas of polymer processing and compounds. Fluoroguard™ PCA is used for enhancing product performance, while also providing processing benefits. Fluoroguard™ SG is an especially purified form and meets USP Plastics Class VI requirements (NAMSA tested). Fluoroguard™ PRO is based on low molecular weight oils and primarily intended for use as a process aid.

Typical Properties

Fluoroguard™ is colorless, odorless, chemically inert, and nonflammable. It will act as an opacifier in most polymers, due to the different refractive index compared to base polymers. The typical properties of Fluoroguard™ are given in Table 1. The results of Fluoroguard™ PCA-compounded materials are discussed in this literature.

Compounding

Fluoroguard™ can be incorporated into the polymer matrix by using conventional melt compounding equipment (Figure 1). Some Fluoroguard™ PCA and SG grades can be processed at temperatures as high as 360 °C (680 °F), because of excellent thermal stability and low volatility. Fluoroguard™ PRO is designed as a processing aid and should be used at temperatures below 177 °C (350 °F), due to volatility. The recommended loading of Fluoroguard™ is 0.1–1.0%, depending on the base polymer matrix and final performance desired. To realize efficient Fluoroguard™ incorporation, a twin-screw extruder with liquid injection capability is most suitable for compounding this additive with thermoplastic polymers. For thermosetting polymers, a normal mixing procedure (internal mixer or other high shear mixer) can be followed.

Figure 1. TPU with Different Fluoroguard™ Loading Levels

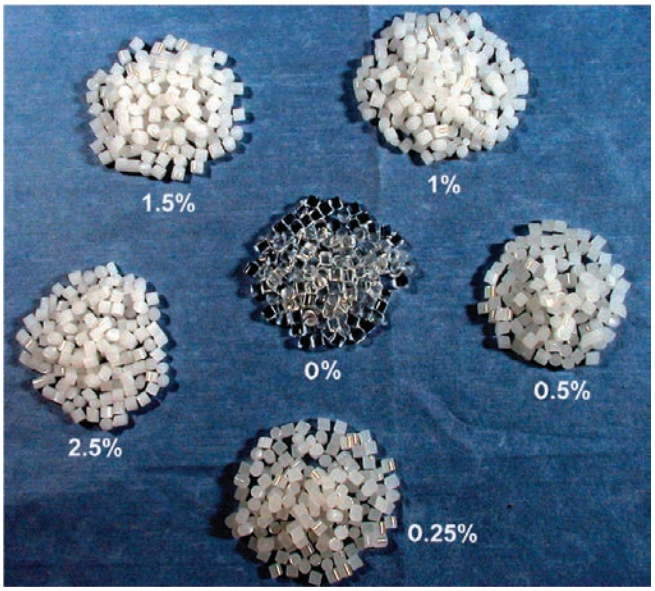


Table 1. Typical Properties of Fluoroguard™ Polymer Additives

Properties	Units/Conditions	Typical Values		
		PRO	PCA	SG
Average Molecular Weight	—	1375	4800	4950
Viscosity	cSt at 50 °C (122 °F)	5	101	107
Volatility	22 hr at 121 °C (250 °F)	—	<1.0%	<1.0%
Density	g/mL at 23 °C (74 °F)	1.9	1.9	1.9
Surface Tension	dyn/cm at 26 °C (79 °F)	18	18	18
Refractive Index	nD25	1.3	1.3	1.3
Pour Point	°C (°F)	<-70 (<-94)	<-36 (<-33)	<-36 (<-33)
Appearance	—	Clear liquid	Clear liquid	Clear liquid

Fluoroguard™ Benefits and Features

- Reduces wear and abrasion
- Eliminates plateout and die buildup
- Improves extrusion rate
- Reduces machine torque and noise
- Improves melt flow and mold release
- Eliminates polymer stickiness
- Has little or no effect on physical properties
- Eliminates marring and scratching
- Reduces/eliminates squeak/sticking
- Has no adverse effects on adhesion
- Is inert to polymers and other chemicals
- Thermally stable to 360 °C (680 °F)

In addition to these advantages, it has also been observed that there is little or no change in initial and aged physical properties of polymer compounds containing Fluoroguard™.

"Fluoroguard™ internally lubricates parts to improve their mechanical performance, without affecting their chemical properties," explains Bruce Ulissi, segment manager for Chemours. "This excellent lubricity helps reduce wear and can eliminate the need for external lubrication."

Compound Processing

Compounds containing Fluoroguard™ can be processed in conventional thermoplastics processing equipment. Before processing compounds, the equipment should be cleaned thoroughly and purged, followed by priming with polymer compounded with Fluoroguard™. Please review SDS and SPI safety and operation guide for processing (e.g., injection molding and extrusion).

Surface Characteristics

Fluoroguard™ improves the surface properties of finished polymer products. It blooms to the part surface and helps in reducing wear and coefficient of friction (COF). Figure 2 shows the presence of Fluoroguard™ on the surface of TPU plaque. ESCA showed that the surface coverage is increased with the increase in Fluoroguard™ loading in PVC (Table 2).

Figure 2. SEM Photographs of Molded Plaque Surface of a) TPU and b) TPU with 0.25% Fluoroguard™

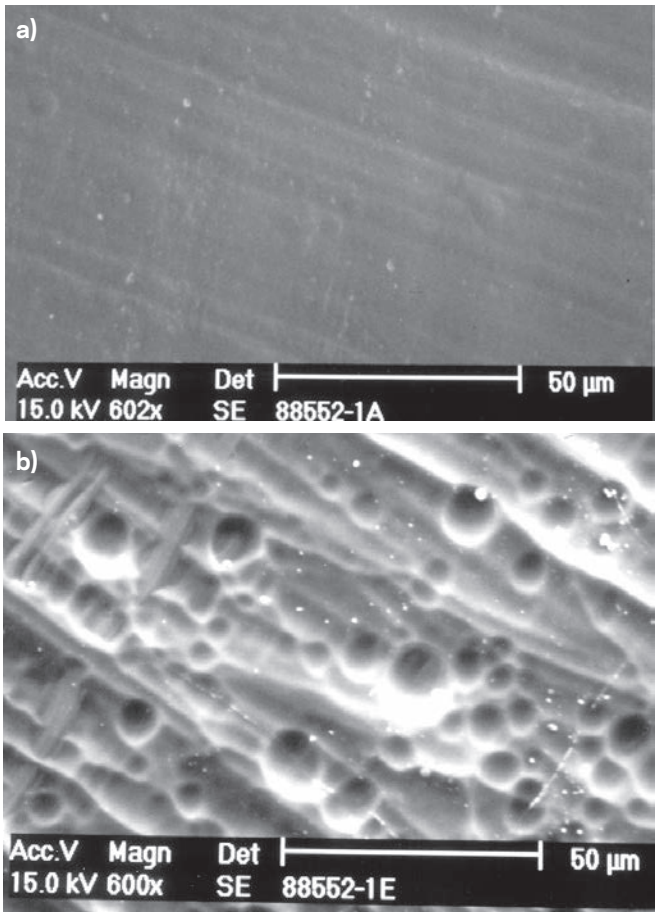


Table 2. ESCA on PVC Plaque

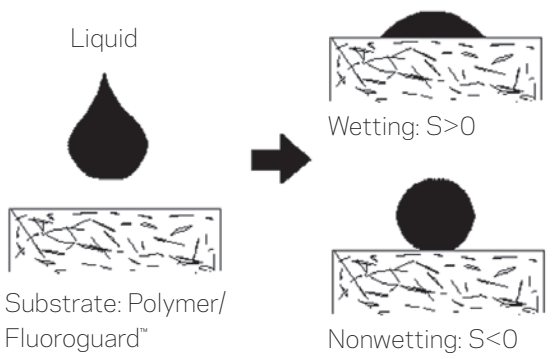
Fluoroguard™ Loading, %	Surface Coverage by Fluoroguard™, %
0.1	35
0.5	66
1.0	88

The presence of Fluoroguard™ on the polymer surface is also supported by contact angle measurement data (Table 3). A contact angle greater than the control TPU indicates the presence of Fluoroguard™ on the polymer surface and the spreading coefficient is less than zero (Figure 3). This is a desirable effect of a processing aid that enhances the flow and release properties of polymers.

Table 3. Contact Angle Data

	Contact Angles (°)	
Materials	Deionized Water	Hexadecane
TPU	97.0	28.7
TPU/0.25% Fluoroguard™	102.7	31.8
TPU/1.0% Fluoroguard™	104.5	33.3

Figure 3. Schematic Diagram: Wetting and Nonwetting



Spreading Coefficient (S) = Surface Energy of Substrate – (Surface Tension of Liquid + Interfacial Tension)

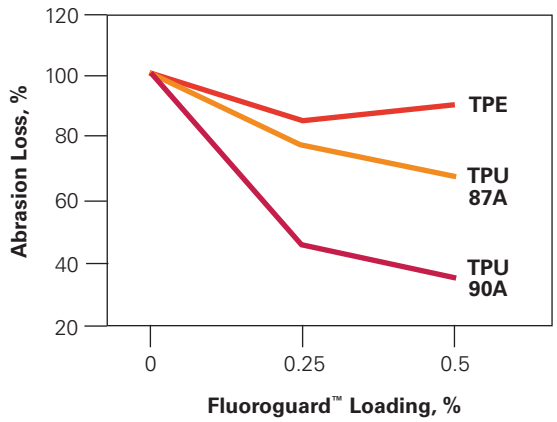
Melt Viscosity

Fluoroguard™ improves the melt flow properties of polymers, resulting in improved processing. The rheological study using a capillary rheometer showed that Fluoroguard™ significantly reduced melt viscosity 20–40%. For example, 0.5% Fluoroguard™ reduces the shear viscosity of Delrin® 100P (acetal) by 20% at 1000 s^{-1} shear rate.

Abrasion Resistance

Fluoroguard™ will create a lubricating film on the product surface, which will reduce wear and abrasion. Figure 4 shows the Taber abrasion loss of different thermoplastic rubbers containing Fluoroguard™. The abrasion loss is represented as percentages (control as 100%). Fluoroguard™ reduces the abrasion loss by 10–60%, depending on the Fluoroguard™ loading and base polymer.

Figure 4. Abrasion Resistance of Thermoplastic Elastomers



Mar and Scratch Resistance

Mar and scratch resistance of polymers is improved with the use of Fluoroguard™. A loading of 0.25% Fluoroguard™ in TPU eliminated marring and scratching per GM 9150-P test (Table 4).

Table 4. Mar and Scratch Resistance

Materials	Results
TPU	Marring /Scratching
TPU/0.25% Fluoroguard™	No Marring /Scratching
TPU/0.50% Fluoroguard™	No Marring /Scratching
TPU/1.00% Fluoroguard™	No Marring /Scratching

Mechanical Properties

Fluoroguard™ improves tensile properties of polymer compounds, with little or no deterioration of other properties. Table 5 shows that tensile strength and elongation at break are significantly increased with the addition of 0.25% Fluoroguard™ in TPU and TPE. Similar improvements are also observed in polymer films. For example, the addition of 0.1% Fluoroguard™ improves the tensile strength of SEBS and polyetheramide block copolymer (PEBA) films by 93% and 20%, respectively.

Table 5. Tensile Properties of Polymers

Polymer	Fluoroguard™ Loading, %	Tensile Strength at Break, psi	Elongation at Break, %
TPU	0.00	7660	737
	0.25	8140	910
	0.50	7720	490
TPE	0.00	3240	808
	0.25	3760	892
	0.50	3730	880

Fluoroguard™ permits engineers to tailor properties of engineering polymers for a specific application. In polymer gear and bushing applications, resins such as acetal and nylon are required to provide low friction and good wear and flex fatigue resistance. A small amount of Fluoroguard™ helps in boosting these properties further with little or no change in other properties (Table 6). It has been found that Fluoroguard™ reduces COF by 30% and increases flex fatigue resistance by 25% of acetal resins. Fluoroguard™ will also eliminate die buildup and plateout, thus reducing costly downtime.

Polymer Wear

Fluoroguard™ significantly improves the wear resistance of polymers. This helps in increasing the service life of polymer gears, bearings, and other products. Figure 5 shows that the addition of 1% Fluoroguard™ reduces the wear of acetal by 97% and nylon 6 by 58%.

Figure 5. Polymer Wear per ASTM 3702 (vs. 1018C Steel at 40 psi, 50 ft/min)

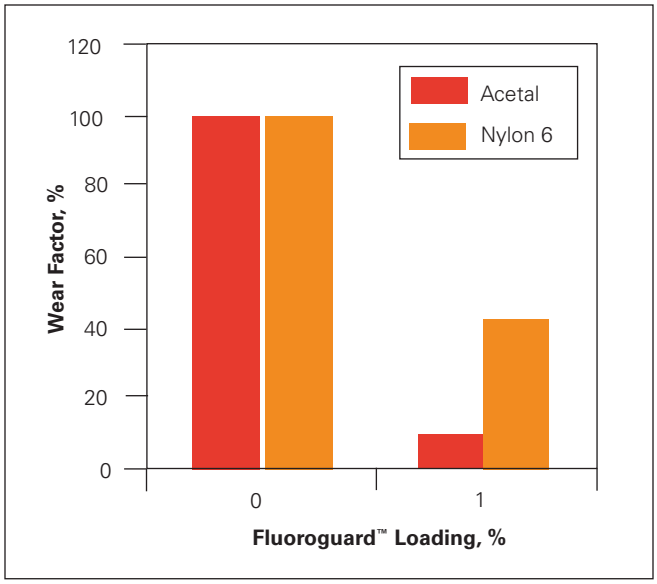


Table 6. Mechanical Properties of Polymers

Polymer	FG Loading, %	Tensile Strength at Yield, psi	Elongation at Yield, %	Flexural Modulus, psi	Unnotched Izod Impact Strength, ft-lb/in	Mold Shrinkage, in/in
Acetal	0.00	9236	9.9	380	24.6	0.0238
	0.50	9275	10	400	31.3	0.0205
Nylon	0.00	12170	10	450	42.7	0.0152
	0.50	11460	8.3	440	38.5	0.0137

Typical Applications

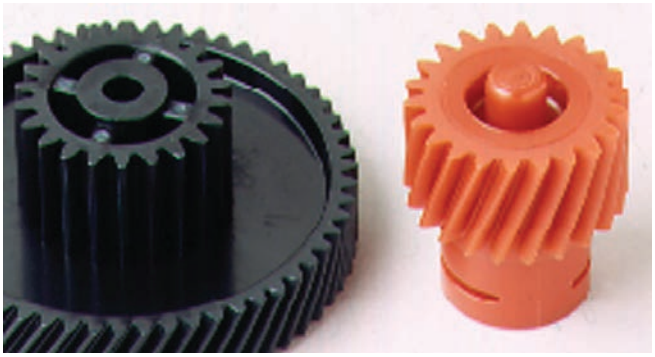
Fluoroguard™ is the product of choice where low wear and abrasion, squeak and noise reduction, lubricity, improved melt flow and release properties of polymer compounds are primary requirements.

Typical application areas are the following:

- Polymer gear/bushings
- Auto weather stripping and interiors
- Shoe soles and cleats
- O-rings/seals
- Polymer films
- Processing aids
- Cable liners

Handling and Safety

Prior to handling and using Fluoroguard™, please review the most current Safety Data Sheet (SDS) and follow recommended label directions and handling precautions. The SDS will help you satisfy your own handling, storage, and disposal considerations and those that may be required by OSHA.



For more information, visit www.fluoroguard.com

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