Precipitated Silica Solutions for Industrial Rubber Applications

A Global Pioneer

Precipitated silica is colorless, odorless and chemically inert, yet the interaction between silica particles and rubber is so important for the performance of composites that few rubber compounders regard it as a commodity product.

That is why, for more than 80 years, high-quality rubber manufacturers around the world have chosen to make PPG silica products integral to their product formulations. Many of these global relationships took root in the 1930s, when engineers from PPG's Barberton, Ohio plant first began working with rubber producers in nearby Akron to explore the potential for synthetic precipitated silica products as reinforcing fillers.

Today, that dual legacy of innovation and customer collaboration endures. With manufacturing operations in Lake Charles, Louisiana; Barberton, Ohio; and Delfzijl, Netherlands; and a growing network of international distributors, PPG is strategically positioned to deliver its broad range of precipitated silica solutions to customers throughout the world.

With the introduction of chemically-modified AGILON® performance silica and other advanced products, PPG continues to develop products that enable rubber manufacturers to create goods that last longer, perform better and contribute to a healthier, safer and more sustainable planet.

Teamwork, Chemistry and Rubber Expertise

For many leading rubber compounders and manufacturers, a principle benefit of working with PPG is access to its extraordinary technical capabilities.

During its history, PPG has accumulated vast institutional knowledge about the formulation and performance characteristics of precipitated silica and how silica form and function affect rubber chemistry. As a consequence, PPG scientists and technical service experts often are called upon to help customers develop and refine products that better meet increasingly challenging performance demands.

The PPG Monroeville Business and Technical Center supports this collaborative model. Located near PPG's global headquarters in Pittsburgh, Pennsylvania, USA, the facility houses a full-scale pilot plant and laboratories containing a wide range of ingredients, mixing equipment and process technologies.

Together, these materials and equipment enable PPG scientists and technical service experts to replicate the entire product development process – from experimental silica manufacturing to production, testing and analysis of customized rubber compounds.

Products and Performance for Every Application

PPG offers a full range of industry-leading silica products. In addition to optimized processing characteristics such as faster cure rates, easier mixing, improved flow, or more flexible extrusion and color-compounding capabilities, PPG's silica technologies also impart specific properties to finished high-performance products.

Compared to rubber compounds using carbon black fillers with similar surface areas, these characteristics include:

- Increased stiffness and reinforcing strength
- Enhanced resistance to heat build-up
- Better tear strength with equal tensile strength
- Improved color retention and/or translucence
- Superior chip and chunk resistance
- Extended product life in high-temperature environments

The PPG Monroeville Business and Technical Center houses a full-scale pilot plant and testing laboratory, including tensile testing equipment.

HI-SIL® Reinforcing Silica Fillers

When PPG introduced HI-SIL® precipitated silica in 1948, it represented an industry breakthrough. In addition to being more dispersible than other reinforcing fillers of the era, *Hi-Sil* silica products were the first of their kind to be cost-competitive with carbon black.

Today, *Hi-Sil* reinforcing fillers remain among the best-known and most trusted brands in the industry, encompassing a broad range of materials engineered to help end-users achieve specific processing and performance requirements.

As with the original *Hi-Sil* product, each silica formulation is skillfully controlled by PPG for surface area, particle size and other physical properties to regulate finished characteristics such as reinforcing strength, dispersibility, viscosity, cure-rate, compression set, and abrasion-, tear- and temperature-resistance.

PPG Semi-Reinforcing Fillers

PPG semi-reinforcing fillers are designed with lower surface areas to limit stiffness, lower compression-set, control heat build-up and improve dynamic modulus and resilience. As a result of their lower surface areas, these silicas provide excellent flow, smoother extrusions and faster cure rates than high-surface-area silica products.

Typical Properties—Semi-Reinforcing

Product	N2 Surface Area, BET-5 (m^2/g)	pH	Residual Salt Type	Physical Form	Source Country
SILENE™ 732D	33	8.5	Na_2SO_4	Powder	United States
Hi-Sil 532EP	55	8.0	Na_2SO_4	Powder	United States

PPG Reinforcing Fillers

PPG reinforcing fillers are formulated to strike a balance between desired physical properties such as stiffness, tensile strength, heat- and abrasion-resistance and processing ease.

Typical Properties—Reinforcing

Product	N2 Surface Area, BET-5 (m^2/g)	pH	Residual Salt Type	Physical Form	Source Country
Hi-Sil 315-D	125	7.0	Na_2SO_4	Powder	Netherlands
Hi-Sil 315G-D	125	7.0	Na_2SO_4	Granule	Netherlands
Hi-Sil 210	135	7.0	NaCl	Pellet	United States
Hi-Sil 233	135	7.0	NaCl	Powder	United States
Hi-Sil 243LD	135	7.0	NaCl	Granule	United States
Hi-Sil 900	135	7.0	Na_2SO_4	Powder	United States
Hi-Sil 135	150	7.0	Na_2SO_4	Powder	United States
Hi-Sil 233-D	150	7.0	Na_2SO_4	Powder	Netherlands
Hi-Sil EZ160G-D	160	7.0	Na_2SO_4	Micro-Granule	Netherlands
Hi-Sil EZ160G	160	7.0	Na_2SO_4	Micro-Granule	United States

PPG Highly Reinforcing Fillers

PPG highly reinforcing silica products are engineered to maximize tensile strength, compound stiffness, thermal-resistance, abrasion-resistance and other wear properties.

Typical Properties—Highly Reinforcing					
Product	N2 Surface Area, BET-5 (m^2/g)	pH	Residual Salt Type	Physical Form	Source Country
Hi-Sil 255C-D	175	6.3	Na_2SO_4	Powder	Netherlands
Hi-Sil 255CG-D	175	6.3	Na_2SO_4	Micro-Granule	Netherlands
Hi-Sil 134G	180	7.0	Na_2SO_4	Micro-Granule	United States
Hi-Sil 132	180	7.0	Na_2SO_4	Powder	United States
Hi-Sil 190G	195	6.5	Na_2SO_4	Micro-Granule	United States
Hi-Sil EZ200G	300	7.0	Na_2SO_4	Micro-Granule	United States
Hi-Sil EZ200G-D	300	7.0	Na_2SO_4	Micro-Granule	Netherlands

Silica and the Dynamics of Dispersibility

Rubber compounders around the world favor PPG silica products for their excellent dispersion characteristics.

Dispersibility and incorporation time of silica into rubber compounds is determined by many factors beyond the formulation of the product itself, including mixer type, rotor design, silica loading, polymer system and the size and physical form of the finished silica particles.

PPG manufactures products with HDS-like physical properties, many of which are identified by the “EZ” designation in the brand name; however, rubber compounders are encouraged to consult their PPG sales and technical representatives to determine which silica grades are most appropriate for their specific applications.

AGILON® Performance Silica Products

A New Technology Platform for Enhanced Dynamic Properties and Extended Wear Resistance

For decades, industrial rubber manufacturers and custom-mixers have fine-tuned compounds with the same additives and ingredients, producing incremental improvements in processing and performance.

AGILON® performance silica products are engineered to change that dynamic. Based on proprietary PPG technology, *Agilon* performance silica products are made by reacting silica, silane and functional additives during the precipitation process, resulting in a single, advanced compounding ingredient.

The Processing Ease of Low-Surface-Area Silica. The Reinforcing Strength of High-Surface-Area Silica.

The result of this innovative process is a next-generation reinforcing silica that combines the performance benefits of a premium, silane-coupled precipitated silica – including exceptional resistance to abrasion, tear and heat build-up – with the process advantages of carbon black.

Because of their unique composition and elevated performance characteristics, *Agilon* silica products can help rubber compounders overcome the limitations associated with conventional filler products; offering instead, a powerful new platform for experimentation in a wide range of high-friction, high-heat and dynamic-motion applications such as brake pads, printing blankets, motor mounts, ultra-long conveyor belts and more.

Less Complexity. More Diversity.

In addition, because *in-situ* mixing of silica and silane no longer takes place at the plant level, *Agilon* performance silica products can help rubber manufacturers ease process complexity, address environmental concerns and reduce capital investment by enabling them to:

- Process silica compounds using older mixing technologies
- Increase silica throughput by reducing mix times and/or passes
- Mix at high temperatures without increasing viscosity or causing premature vulcanization
- Mix at lower temperatures to avoid degradation of natural rubber
- Extend the shelf life of uncured rubber
- Minimize process-related energy consumption
- Eliminate most alcohol-related VOC emissions

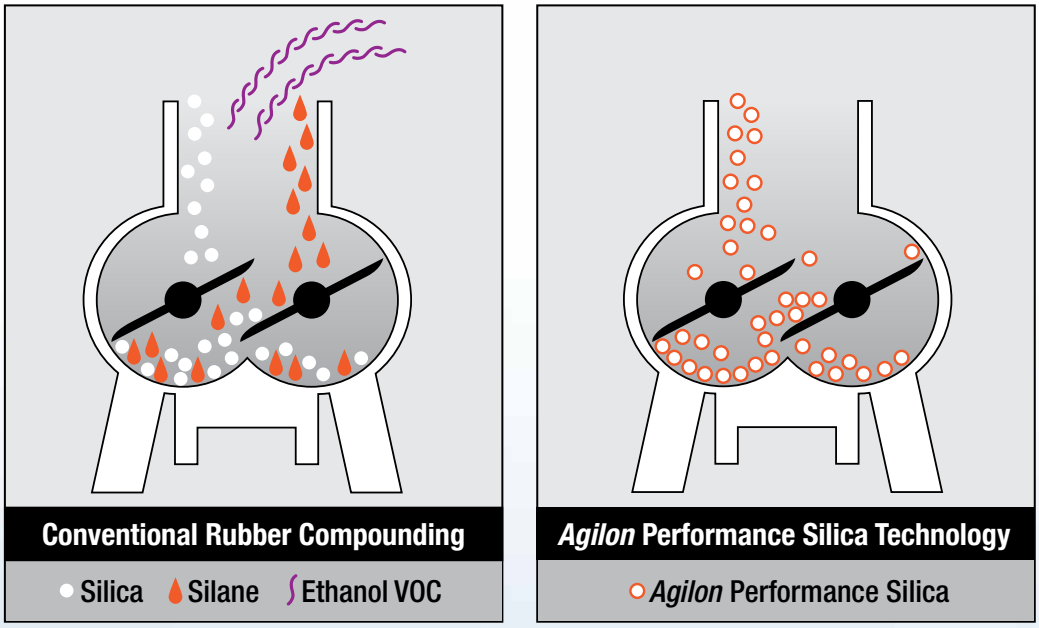
In addition, *Agilon* performance silica, when used at a maximum level of 60 phr, may be used in the manufacture of repeated-use rubber food-contact articles. It complies fully with the United States Federal Food, Drug and Cosmetic Act and all applicable food additive regulations, including the applications described under section 177.2600.

Typical Properties—*Agilon* Performance Silica

Product	Dispersibility	Reinforcing Capability	CTAB Surface Area (m^2/g)	N2 (BET-5) Surface Area (m^2/g)	SH, Weight %	Carbon, Weight %	pH	Residual Salt	Physical Form Type
Agilon 400	High	High	140	75	0.5	4.0	6.5	Na_2SO_4	Granule or Powder
Agilon 454	High	High	200	140	0.5	4.0	6.5	Na_2SO_4	Granule or Powder
Agilon 458	High	High	200	115	0.5	6.0	6.5	Na_2SO_4	Granule or Powder

N2 (BET-5) surface area test results are impacted by the surface treatment applied to Agilon *performance silicas. Customers should reference CTAB surface area values as a better predictor of this material's reinforcement capability.*

Conventional Rubber Compounding vs AGILON® Performance Silica Technology



In traditional rubber manufacturing, silica and silane often are mixed during the compounding process. With *Agilon* performance silica, silica and silane are reacted during the silica production process and delivered as a single advanced compounding ingredient, reducing mix times, increasing throughput and cutting emissions, all while imparting premium performance characteristics.

PPG Silica Products by Performance Attribute

Industrial Rubber Product Selector

PPG Silica Categories	Semi-Reinforcing	Reinforcing	Highly Reinforcing	*Agilon* Performance Silica
Abrasion Resistance	●	● ●	● ● ●	● ● ●
Tear Strength	●	● ●	● ● ●	● ●
Tensile Strength	●	● ●	● ●	● ● ●
Rebound	● ● ●	● ●	●	● ● ●
Processing	● ● ●	● ●	●	● ● ●
Mix Time	●	●	●	● ● ●
Heat Build-Up	● ● ●	● ●	●	● ● ●
Compression-Set	● ● ●	● ●	●	● ● ●
Stiffness	●	● ●	● ● ●	● ●
	No Silane	***No Silane***	***No Silane***	***Silane Treated***

● Good ● ● Better ● ● ● Best

PPG Silica Products global headquarters is based in Monroeville, Pennsylvania, USA

Personal Attention. On a Global Scale.

PPG is committed to the success of the global rubber industry and the individual customers it serves. That pledge is reflected in PPG's ongoing pursuit of groundbreaking technical developments as well as reliable delivery and consistent silica product performance.

Consistent Quality with Every Application

Along with industry-leading testing, analytical and problem-solving capabilities, PPG maintains state-of-the-art process controls at its manufacturing plants and follows strictly the quality standards and testing methodologies established by the American Society for Testing and Materials (ASTM) and International Organization for Standardization (ISO).

These rigid quality standards ensure that PPG products consistently maintain stated values for surface area, moisture, pH content and other critical manufacturing specifications, as long as they are properly stored and handled.

Right-Sized Customer Service

Even more valuable are the benefits of world-class technical service and sales support. As a multi-billion dollar global company, PPG has the ability to deliver its products and services to customers in every part of the world. Yet, as a dedicated business within that organization, the PPG Silica Products group provides the personalized focus of a small, family-owned company, supplying a broad portfolio of materials in a variety of package sizes and pallet configurations to best meet customer needs.

Whether the goal is to improve an existing compound or to explore the potential of an entirely new technology platform, PPG offers the global resources and personal attention needed to help industrial rubber manufacturers meet today's demands and anticipate tomorrow's challenges.

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