CREATING TOMORROW’S SOLUTIONS

PLASTICS INDUSTRY | PERFORMANCE ADDITIVES

SILANES AND SILICONES FROM WACKER: BETTER YET – ADD PERFORMANCE TO YOUR PLASTICS!
Cars, cables, shoes, packaging, pipes, films, toys ... plastics are part of our world. And as our world changes, the demands for plastics change, too. At WACKER we help you meet these demands with unique expertise in organic and inorganic chemistry.
From lightweight constructions in cars or airplanes to toys and packaging: plastics continue to play an increasing role in everyday life. But as application areas become broader, the performance demands grow, too. WACKER silicones and silanes make it possible to meet these demands cost efficiently.

New applications open up new possibilities for plastics. But they also require plastics with new characteristics. To meet these requirements, there are two options. One is to develop novel plastics with a greater property profile: a challenging task with usually high development costs, large capital investment and long development cycles. The other is to modify existing plastics through innovative additive technology: an option which is more and more popular due to its cost efficiency.

This is reinforced by the dynamic growth of the plastic additives market worldwide. Innovation in plastics has been proven to come from additives and the performance enhancement that they provide. To realize this potential, WACKER offers you a wealth of different solutions.

WACKER is a leading chemical company with extensive expertise in silane- and silicone-based chemistry. We understand organic and inorganic chemistry, offering you innovative additives which add superior characteristics to thermoplastics.

**GENIOPERL®, GENIOPLAST®, GENIOSIL® and WACKER® are registered trademarks of Wacker Chemie AG.**
There are various ways to enhance the performance of plastics. With WACKER you have them all at hand – from one single source.

**Your Benefit**
Dealing with one partner is easier and provides better results faster. Our silicones and silanes can be used at different stages of the value chain, individually or combined. This opens up choices and makes our experts valuable partners: they know from experience what will work and what the effects will be. This know-how is part of our product offering.

**Our Offering**
Silanes and silicones are not only essential aids for designing polymers chemically; they can also be added to polymers to modify their properties, e.g. to enhance demolding properties and surface smoothness, to maximize impact strength and flexibility, even at low temperatures, to raise resistance to environmental influences, and to distribute the filler more uniformly in the polymer while reinforcing the bond between them.

Silanes and silicones from WACKER can be used:
- For polymerization catalysis
- As process chemicals and additives
- For polymer modification
- For polymer crosslinking
STANDARD PLASTICS
CONTROLLING PROPERTIES:
DONOR SILANES

Production of polyethylene and polypropylene by polymerization of olefins in the presence of Ziegler-Natta catalysts is carried out on an industrial scale and is of major economic importance.

Unlike polyethylene, polypropylene and its copolymers must be stereospecific if the end products are to be of high quality and have good polymer properties. Production is therefore closely controlled to ensure a high yield of isotactic polymer. Stereospecificity can be boosted by adding special alkyl-alkoxysilanes to the catalyst. This not only increases the yield of isotactic polypropylene and promotes catalytic activity but also affords a way of controlling other important polymer properties, such as molecular weight and molecular weight distribution. Silane CHM-Dimethoxy ("donor C") and Silane CP2-Dimethoxy ("donor D") are used around the world as “donor silanes” for the production of polypropylene. Silane CHM-Dimethoxy is mainly used to manufacture PP homopolymer, and Silane CP2-Dimethoxy is primarily for PP copolymers.

The convenience of consumer goods would be unimaginable without plastic. At the same time packaging must fulfill many expectations – such as cost efficiency, high or low temperature resistance, food compliance, biodegradability. Additives are a resourceful way to balance characteristics in line with these expectations.

### WACKER Silanes for the Production of Polypropylene

<table>
<thead>
<tr>
<th>Silane</th>
<th>Chemical Name</th>
<th>Structural Formula</th>
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<tbody>
<tr>
<td>CHM-Dimethoxy</td>
<td>Cyclohexylmethylidimethoxysilane</td>
<td><img src="image" alt="CHM-Dimethoxy" /></td>
</tr>
<tr>
<td>CP2-Dimethoxy</td>
<td>Dicyclopentyldimethoxysilane</td>
<td><img src="image" alt="CP2-Dimethoxy" /></td>
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Silane crosslinking technology makes it possible to convert inexpensive thermoplastic polymers into crosslinked polymers. The result is a great improvement in heat and dimensional stability, electrical conductivity and creep characteristics as well as weatherability.
STANDARD PLASTICS
UPGRADING QUALITY: POLYETHYLENE CROSSLINKING AND COUPLING

Today, silane crosslinking is an established way of producing low and medium voltage cable from crosslinkable polyethylene (PEX). But technological diversity, economics and the new olefins produced by metallocene catalysis are opening up numerous other new applications. These include production of PEX pipes commonly used for hot water and underfloor heating, transfer of polyethylene technology to ethylene copolymers and polypropylene, development of new process technologies for single-parts production and the production of polyolefin foams.

PEX compounds may be produced and processed by either the SIOPLAS or the MONOSIL methods in which vinylalkoxy silanes are grafted onto the polyethylene. As with the SIOPLAS method, it is also possible to process PE and copolymer compounds produced by direct copolymerization of ethylene, vinylalkoxy silane and, where appropriate, other monomers.

GENIOSIL® XL 10 and GENIOSIL® GF 56 are used for silane crosslinking and the production of crosslinkable polyolefin compounds. Faster crosslinking catalysts and the development of ambient curing systems require better storage stability of SIOPLAS compounds. Here, WACKER® Silane HD-Trimethoxy is used as a water scavenger and precuring retarder. This can increase shelf life as well as safety in the handling and processing of silane crosslinkable compounds.

GENIOSIL® GF 51 is applied in compounds for flexible filled rubber cables and, unlike other state-of-the-art coupling agents, does not release SVHC when applied.

WACKER Silanes for Polyethylene Crosslinking and Coupling

<table>
<thead>
<tr>
<th>Silane</th>
<th>Chemical Name</th>
<th>Chemical Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENIOSIL® XL 10</td>
<td>Vinyltrimethoxysilane</td>
<td>H₂C=CHSi(OCH₃)₃</td>
</tr>
<tr>
<td>GENIOSIL® GF 51</td>
<td>Formulated product</td>
<td></td>
</tr>
<tr>
<td>GENIOSIL® GF 56</td>
<td>Vinyltriethoxysilane</td>
<td>H₂C=CHSi(OC₂H₅)₂</td>
</tr>
<tr>
<td>WACKER® SILANE HD-Trimethoxy</td>
<td>Hexadecyltrimethoxysilane</td>
<td>C₁₆H₃₃Si(OCH₃)₃</td>
</tr>
</tbody>
</table>

Standard Plastic

The SIOPLAS Process

Polyethylene Silane Initiator

Mixing Compounding (grafting reaction) Pelletizing

Crosslinkable graft polymer

Mixing Extrusion

Crosslinking

Polyethylene Crosslinking catalyst Antioxidant

Mixing Compounding Pelletizing

Catalyst masterbatch

The MONOSIL Process

Polyethylene Antioxidant Silane Initiator Crosslinking catalyst

Metering Compounding (grafting reaction) Extrusion

Crosslinking
**WACKER Product**  | **Chemical Characteristics** | **Physical Characteristics**
--- | --- | ---
**GENIOPLAST® Pellet S**  | Ultrahigh-molecular-weight polydimethylsiloxane in pellet form  | White translucent cylindrical pellets, diameter and length each approx. 4 mm
**GENIOPLAST® Pellet P Plus**  | Ultrahigh-molecular-weight polydimethylsiloxane in pellet form for food-contact applications  | White translucent cylindrical pellets, diameter and length each approx. 4 mm
**GENIOPLAST® PP50S12**  | Ultrahigh-molecular-weight polydimethylsiloxane masterbatch on PP carrier  | White pellets of approx. 3–4 mm; also available as microgranules of approx. 1 mm
**GENIOPLAST® PP20A08**  | Silicone copolymer masterbatch on PP carrier  | White pellets of approx. 3–4 mm
**GENIOPLAST® Pellet 345**  | Thermoplastic silicone elastomer based on proprietary silicone copolymer technology  | Transparent pellets of approx. 3–4 mm
**GENIOPLAST® Fluid FR**  | Formulation comprising high-molecular-weight polydimethylsiloxane and silicone resin  | Clear, colorless, high-viscosity fluid, typical viscosity approx. 500,000 mm²/s
**GENIOPLAST® Fluid 110**  | Food-compliant silicone based additive specifically for PVC applications  | Clear, colorless, low-viscosity fluid
**GENIOPLAST® Fluid 220**  | Silicone based additive specifically for polyolefin applications  | Clear, colorless, medium-viscosity fluid
**WACKER® AK Silicone Fluids (AK 100 – AK 1,000,000)**  | Polydimethylsiloxanes  | Clear, colorless fluids; relevant viscosity range: 100 – 1,000,000 mm²/s
**WACKER® Fluids IM and NH**  | Linear polydimethylsiloxanes with terminal organofunctional (carbinol, epoxy, amino) groups  | Low- to medium-viscosity fluids
**GENIOPERL® P 15**  | Polysilsesquioxane (silicone resin) microparticles  | White powder
**GENIOPERL® P 52**  | Core-shell particles consisting of a crosslinked silicone core and a shell based on an organic polymer  | White powder
**GENIOPERL® W 35**  | Functionalized silicone copolymer  | Opaque, lens-shaped pellets, diameter/thickness approx. 5 mm/2 mm

From smartphones to portable media players: plastics are an essential part of our lives. Additives ensure that the plastic has the desired properties and improve its processability.
GENIOPLAST® and WACKER® AK Silicone Fluids are perfect products for processing and modifying thermoplastic resins. They find applications as compounding additives for standard plastics as well as for engineering plastics.

General Benefits for Thermoplastic Polymers

On addition of 0.1 – 1%:
- Improved processing and flow properties
- Less extruder torque
- Significantly faster throughput
- Internal lubrication
- Better mold filling and mold release
- Reduced warpage of moldings

On addition of 1 – 5%:
- Better surface properties for the moldings
- Improved surface smoothness
- Lower coefficient of friction
- Greater scratch and abrasion resistance
- Better mechanical properties

Specific Gains

GENIOPLAST® Pellet S
GENIOPLAST® Pellet S is a unique product concept, providing an outstanding high loading of ultrahigh-molecular weight polydimethylsiloxane and general compatibility with thermoplastic resins. Major applications of GENIOPLAST® Pellet S comprise improved processing of cable compounds. GENIOPLAST® Pellet S is also applied for better processing and surface properties in engineering plastic compounds and for thermoplastic elastomers.

GENIOPLAST® Pellet P Plus
GENIOPLAST® Pellet P Plus provides the same benefits as GENIOPLAST® Pellet S but has been specifically developed for applications where food-contact regulations must be met.

GENIOPLAST® PP50S12
GENIOPLAST® PP50S12 is a 50% silicone gum masterbatch on PP carrier and has been specifically designed for automotive interior applications. Contrary to amides and other fatty acids, GENIOPLAST® PP50S12 does not migrate and bloom outside the interior part. Therefore, GENIOPLAST® PP50S12 does not contribute to fogging and stickiness. Main benefits are improvement of scratch performance and improvement of surface aspects (soft touch, not sticky, non-blooming).

GENIOPLAST® PP20A08
GENIOPLAST® PP20A08 is a 20% masterbatch of a proprietary silicone copolymer on PP carrier and has been specifically designed for WPC (wood-plastic composite) applications. Unlike standard lubricants (stearates, PO waxes, long chain amides), GENIOPLAST® PP20A08 does not influence the coupling agent and, in a low dosage (1 – 3%), has no impact on mechanical properties. Its main benefits are improvement of water absorption, reduced swelling and enhanced scratch resistance in WPC decking.

GENIOPLAST® Pellet 345
GENIOPLAST® Pellet 345 is a thermoplastic silicone elastomer based on a proprietary silicone copolymer technology. Used as an additive at a dosage level of up to 5%, GENIOPLAST® Pellet 345 improves the surface properties of organic polymers (slip, non-adhesion, scratch resistance) as well as the processing of certain TPEs. Applied in polymer blends (e.g. TPU or TPA) in amounts of 10% and above, GENIOPLAST® Pellet 345 additionally modifies physical properties (e.g. hardness, modulus and elongation).
GENIOPLAST® Fluid FR
GENIOPLAST® Fluid FR, a silicone-based flame-retardant additive, is specifically applied when balanced requirements regarding processing, surface properties and thermal/mechanical characteristics must be met.

GENIOPLAST® Fluid 110 and Fluid 220
GENIOPLAST® Fluid 110 has an outstanding property profile which sets it apart from conventional internal and external lubricants, improving e.g. processing, thermal stability and mechanical properties. GENIOPLAST® Fluid 220 has been developed as an additive specifically for processing of highly mineral-filled, crosslinkable polyolefin compounds.

WACKER® AK Silicone Fluids
WACKER® AK Silicone Fluids, available in viscosities ranging from 100 to 1,000,000 mm²/s, provide manifold processing benefits to standard and engineering plastics compounds. As mentioned, the range of benefits varies with the quantity added to thermoplastic resins.

WACKER® Fluids IM and NH
WACKER® Fluids IM and NH are linear polydimethylsiloxanes with terminal functional groups. They can be incorporated by chemical reaction into engineering plastics in the polymer-manufacturing step. Different functional groups – carbinol (IM 11, IM 15, IM 22), epoxy (IM 35), amino (NH 15, NH 30, NH 130) – and silicone chain lengths are available and can help to improve mechanical and flow properties of TPUs, polyester and other engineering resins.

GENIOPERL® P 15
GENIOPERL® P 15 is a polysilsesquioxane microparticle with a defined, narrow, monomodal size distribution. Due to the defined diameter, these particles offer excellent properties as an antiblock in polyolefin films even in very low concentration and therefore could provide high clarity films.

GENIOPERL® P 52
GENIOPERL® P 52 is a particulate polymer modifier in powder form. The spherical, reversibly agglomerated primary particles consist of a low-modulus, crosslinked silicone core and a shell based on an organic polymer. GENIOPERL® P 52 is used in thermoplastic and thermoset formulations to improve the toughness and impact properties.

GENIOPERL® W 35
GENIOPERL® W 35 is a functionalized silicone copolymer in pellet form. GENIOPERL® W 35 is applied in thermoset formulations like epoxy resins or vinyl esters to improve the toughness and impact properties of the cured resins. It is typically used at dosage levels of up to 5% and due to its specific structure the impact on final resin properties is almost negligible.

For more information on GENIOPLAST® and WACKER® AK Silicone Fluids, please refer to the various brochures available.

Target Polymers That Can Be Modified

<table>
<thead>
<tr>
<th>Polymers that stand to benefit from WACKER silicones and silanes:</th>
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<tbody>
<tr>
<td><strong>Standard Plastics</strong></td>
</tr>
<tr>
<td>Polyethylene (PE-LD, PE-LLD, PE-HD), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS, EPS)</td>
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<tr>
<td><strong>Engineering Plastics</strong></td>
</tr>
<tr>
<td>Styrene copolymers (ABS, SAN, ASA), polyamide (PA), polycarbonate (PC), polymethyl methacrylate (PMMA), polyester (PET, PBT), polyacetal (POM), polyphenylene ether (PPE) and blends (PC/ABS, PC/ASA, PPE/PS, PPE/PA etc.)</td>
</tr>
<tr>
<td><strong>Thermoplastic Elastomers</strong></td>
</tr>
<tr>
<td>Styrene block copolymers (SBS, SEBS, SEPS), thermoplastic polyurethanes (TPU), polyolefins (TPO) and copolyester (TPE-E)</td>
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Download the WACKER Square app from the Apple App Store or the Google Play Store and keep up with the media mentioned above.
WACKER is one of the world’s leading and most research-intensive chemical companies, with total sales of €4.93bn. Products range from silicones, binders and polymer additives for diverse industrial sectors to bioengineered pharmaceutical actives and hyperpure silicon for semiconductor and solar applications. As a technology leader focusing on sustainability, WACKER promotes products and ideas that offer a high value-added potential to ensure that current and future generations enjoy a better quality of life, based on energy efficiency and protection of the climate and environment.

Spanning the globe with 4 business divisions, we offer our customers highly-specialized products and comprehensive service via 24 production sites, 23 technical competence centers, 14 WACKER ACADEMY training centers and 51 sales offices in Europe, North and South America, and Asia – including a presence in China. With a workforce of some 14,700, we see ourselves as a reliable innovation partner that develops trailblazing solutions for, and in collaboration with, our customers. We also help them boost their own success. Our technical competence centers employ local specialists, who assist customers worldwide in the development of products tailored to regional demands, supporting them during every stage of their complex production processes, if required. WACKER e-solutions are online services provided via our customer portal and as integrated process solutions. Our customers and business partners thus benefit from comprehensive information and reliable service to enable projects and orders to be handled fast, reliably and highly efficiently.

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All figures are based on fiscal 2019.
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