Silica/Silane System for the Rubber Industry
Silica and silanes for technical & special rubber applications
When it comes to rubber, we are continuously shaping our product portfolio and application know-how to meet our customers’ challenges. The rubber team of Evonik is backed with a full range of silica and silane products and is ready to provide technical support to tailor-design compounds according to your specific needs of reinforcement.

Our precipitated silica and silicates are known under the brand name ULTRASIL®. As the only world-wide supplier with silica and silane, Evonik offers various silane products like e.g. Si 69° and COUPSIL® which are well suited for numerous mechanical rubber goods. Our fumed silica products sold under the brand name AEROSIL® complement the product portfolio of reinforcing white fillers for this industry.
Precipitated and fumed silica can contribute significantly to rubber performance in many applications providing unique benefits. Due to the high surface area and the chemical nature, synthetic amorphous silica provides excellent reinforcement potential and enables you to compound coloured or transparent rubber articles with high strength and durability. Depending on the required reinforcement and necessary processability, the right silica can be chosen from our product portfolio adding excellent tear properties to your rubber articles.

With the use of the right organosilane, the reinforcement capabilities of silica in rubber compounds are brought to an optimum. Chemical crosslinks between two otherwise non-reacting materials are formed during mixing and vulcanization. Even if used in polar rubbers like NBR or ACM, which are compatible with the polar silica, an additional silane coupling reaction – taking place from 120 °C onwards – enhances the strength and the durability of the compound.

Depending on the required reinforcement level the silane dosage needs to be adjusted. Typical silane concentration for mechanical rubber goods varies between 2 to 6 phr.

By offering silane treated silicas, i.e. COUPSIL®, Evonik provides a solution to shorten the compounding process without performance loss. COUPSIL® products are available for sulfur and peroxide cured compounds and may be used directly or in a blend with untreated silica. The benefits of the Silica/Silane system are significantly improved dynamic properties, such as dynamic stiffness and damping behavior (i.e. hysteresis loss). When it comes to the highest requirements in abrasion or tear resistance there is no better choice than this reinforcing filler system. Depending on the type of rubber and the chosen vulcanization system, the required reinforcement is reached by the right choice of silica and silane. The specific surface area of the silica determines the reinforcement capability, but also has an influence on the processability and the preferred filler loading. The best suited silane is determined by the applied curing system: The table on page 4 enables you to choose the right silane for your application.

In some applications bonding of rubber to steel cords or metal parts is of crucial importance. The use of silica improves the bonding ability of your compounds significantly – adding an extra piece of confidence to your rubber metal bond in such applications like conveyor belts or metal carriers for gaskets.
**Suitability by Functionality**

### SUITABILITY BY CURING SYSTEM

<table>
<thead>
<tr>
<th>Diene rubbers (SBR, NBR, BR)</th>
<th>EP(D)M</th>
<th>CR</th>
<th>ACM</th>
<th>ECO</th>
<th>BIIR</th>
</tr>
</thead>
</table>

### TYPE OF CURING SYSTEM

<table>
<thead>
<tr>
<th>Evonik Silane</th>
<th>Functionality</th>
<th>Sulfur, Peroxide</th>
<th>Sulfur, Peroxide</th>
<th>Metal Oxide</th>
<th>Soap / Sulfur</th>
<th>Peroxide / TAIC</th>
<th>Metal Oxide / Sulfur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si 69®</td>
<td>-Sx-</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>XP Si 466 EXT</td>
<td>-S²-</td>
<td>+</td>
<td>++</td>
<td>+=</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Si 264™</td>
<td>- SCN</td>
<td></td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Dynasylan® AMEO</td>
<td>Amino-</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Dynasylan® VTEO</td>
<td>Vinyl-</td>
<td></td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Dynasylan® 6498 or 6598</td>
<td>Methacryl-</td>
<td></td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Dynasylan® MEMO</td>
<td>Epoxy-</td>
<td></td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Dynasylan® MTMO*</td>
<td>Mercapto-</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

*available upon request as triethoxysilane  ++ strongly reinforcing  + reinforcing  †pre-scorch tendency

- Evonik offers silica with different surface areas and delivery forms. Either for mixing in a kneader or on a two-roll mill the dispersion of ULTRASIL® in your compounds may not only be enhanced by choosing a HD (highly dispersible) ULTRASIL® grade but also by using powder instead of granules where appropriate.

- Different polymers require different curing chemistry. Evonik’s product portfolio includes different functionalized silanes such as sulfur-, amino-, vinyl-silanes and others. The right choice of silane chemistry enables you to optimize the silane-rubber-coupling thus taking the best advantage from the Silica/Silane reinforcement potential.

- The silane Si 69® enables the compounder to balance reinforcement and curing behavior in sulfur-cured compounds. The occurrence of a prescorch at mixing temperatures higher than 165 °C should be avoided. At mixing temperatures below 150 °C, e. g. on a two-roll mill, Si 264™ or COUPSIL® products are recommended.

- Peroxide curing is a fast and effective way to achieve good heat stability and excellent compression set properties. In combination with vinyl – or methacryl-silanes, silica provides improved tear resistance and tensile strength of your compounds. In case the low flash point of Dynasylan® VTEO is of concern, we recommend the oligomeric silanes Dynasylan® 6498 or 6598, respectively the pre-reacted silica COUPSIL® VP 6508. Further enhancement of the coupling efficiency is achieved with the co-crosslinkers TAC* and TAICROS** from Evonik.

- To find the optimal solution for our customers, Evonik’s Applied Technology Tire & Rubber team provides global technical support when it comes to testing our Silica/Silane combinations. To give a short overview about application potentials, the next page shows basic information for the use of silica and silanes in different rubber applications and compounds.

*TAC and TAICROS brochures available at Evonik’s Performance Materials Segment
1 Rubber parts for damping and vibration applications like engine mounts are facing extreme dynamic stress. Optimized dynamic properties, excellent metal bonding and highest tear resistance are provided by Silica/Silane systems from Evonik and by ensuring proper silanization with the right silane such as Si 264™, a low compression set can be achieved.

2 In compounds with polar rubbers, e.g. NBR, silica is able to provide an enormous reinforcement potential. Products that require a high rigidity combined with highest abrasion resistance like timing belts and rollers strongly gain benefits from the reinforcement potential of the silica in combination with Si 69™.

3 Conveyor belts transport goods over high distances thus requiring highest stiffness, lowest abrasion, high tear resistance and long durability. With ULTRASIL® VN 3 GR or ULTRASIL® 7000 GR your compounds fulfill these needs. In combination with a silane the performance is further enhanced, e.g. reduced heat build-up. Excellent steel cord bonding can be achieved by usage of COFILL® 11.

4 Fastest processing and perfect appearance of rubber profiles require highest green strength and good flow behavior for optimum extrusion output. With the reinforcement of silica such as ULTRASIL® 880 and ULTRASIL® 360 and in combination with silanes your compounds provide excellent extrusion properties and enable to optimize the tackiness and appearance. The use of VESTENAMER®, which is a thermoplastic synthetic rubber from Evonik, can further improve processability and flow behavior.

5 Solid tires are used for vehicles such as fork trucks that operate in clean environments where black tracks are not accepted. White filled rubber compounds, reinforced by ULTRASIL® VN 3 GR or ULTRASIL® 7000 GR allow products with lowest abrasion leaving no unwanted traces. And when it comes to highest loads and durability, the addition of a coupling agent such as Si 69™ provides highest reinforcement and lowest rolling resistance for your solid tires.

6 Gaskets and seals often require a metal rubber bond and must fulfill a broad range of specifications withstand highest loads in harsh environments. The excellent rigidity of rubber compounds reinforced with Silica/Silane systems and their perfect bonding behavior enable highest stiffness combined with longest elongation and optimized tear resistance. A good compromise between compression set and reinforcement is achieved with ULTRASIL® 360 and in cases where highest tensile strength is required higher surface area silica may be the right choice.

Special polymers such as HNBR, ACM, and FKM are often used for applications with low swell behavior and excellent form stability. In these cases fumed silica i.e. AEROSIL®, may be the perfect choice. Furthermore, AEROSIL® offers the highest transparency in clear compounds.

*VESTENAMER® brochures available at at Evonik’s Business Line High Performance Polymers
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