We give wings to wind power
AEROSIL® fumed silica, Dynasylan® silanes and Protectosil® silanes as essential additives in wind energy applications
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Wind energy

The wind energy market, in particular, will still grow at an above average rate around the world for the next decade. It will be driven by pro-environmental regulations, as well as by a change in the ratio of on-shore to off-shore equipment installed. While off-shore wind turbines provide a higher yield on energy, the demands (salt water and winds, corrosion, etc.) on the materials (steel, resins, adhesives) used will increase. Here Evonik can provide special and tailor-made additives (e.g. AEROSIL®, Dynasylan® and Protectosil®) to make sure that the increased requirements will be met.

AEROSIL® R 202, AEROSIL® R 208 and AEROSIL® R 805 are very effective thixotropes for bonding pastes, laminating resins and gel coats for wind energy applications. Dynasylan® 1124, a secondary amino silane, and Dynasylan® 1146, an oligomeric amino silane, can be used successfully as adhesion promoters in bonding pastes for wind energy applications. Protectosil® BHN, Protectosil® CIT and Protectosil® DRY CIT are very efficient products to protect new and even already cracked concrete fundaments.
Evonik’s silica and silanes products in wind energy applications
Evonik’s silica and silanes products in wind energy applications

Wind turbine bonding pastes
Gel Coats and Top Coats
Glass Fibers
Wind turbine fundamentals

Top Coating: (AEROSIL®, Dynasylan®)
Polyurethane, epoxy, polyester/vinyl ester top coating

Finishing: (AEROSIL®, Dynasylan®)
Epoxy, polyester/vinyl ester, polyurethane gel coating

Priming: (AEROSIL®, Dynasylan®)
Epoxy, polyester/vinyl ester gel coating

Pre-Preg, laminating resin: (AEROSIL®, Dynasylan®)
Epoxy, vinyl ester/UPR

Bonding pastes: (AEROSIL®, Dynasylan®)
Epoxy, vinyl ester/UPR, PU, acrylate
Large quantities of bonding pastes are used in the manufacturing of wind turbine rotor blades. The normal production procedure is to manufacture the upper and lower shell of the rotor blade shell in separate moulds and to glue them together by the bonding pastes. These bonding pastes must have good thixotropic and specific slump properties. That is why AEROSIL® fumed silicas are used as standard thixotropes in bonding pastes based on epoxy, polyurethane and vinyl ester resins. The hydrophobic fumed silicas AEROSIL® R 208 and AEROSIL® R 202 are high-performance thixotropes used in bonding pastes for the manufacturing of rotor blades.

Furthermore, bonding pastes must also have excellent fatigue properties. Structure-modified fumed silica grades like AEROSIL® R 7200, AEROSIL® R 8200 and AEROSIL® R 9200 can adjust bonding pastes with excellent reinforcing properties. Organo-functional silanes like Dynasylan® GLYMO, Dynasylan® AMMO, Dynasylan® 1124, and Dynasylan® 1146 act as an adhesion promoter in bonding pastes, and they can further improve the crosslinking density of suitable bonding pastes.

### Products Delivery Form Characteristics Applications

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<tr>
<th>Products</th>
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</tr>
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<tbody>
<tr>
<td>AEROSIL® R 208</td>
<td>White Powder</td>
<td>Hydrophobic fumed silica</td>
<td>The most efficient thix trope for bonding pastes. Highly hydrophobic behaviour.</td>
</tr>
<tr>
<td>AEROSIL® R 202</td>
<td>White powder</td>
<td>Hydrophobic fumed silica</td>
<td>The thix trope of choice for bonding pastes based on EP, PU, as well as VE resins for the bonding of rotor blades. Excellent storage stability.</td>
</tr>
<tr>
<td>AEROSIL® 200</td>
<td>White powder</td>
<td>Hydrophilic fumed silica</td>
<td>Thix trope for bonding pastes based on unsaturated polyester and MMA resins, and for relatively non-polar amine hardeners for epoxy systems.</td>
</tr>
<tr>
<td>AEROSIL® R 7200</td>
<td>White powder</td>
<td>Structure-modified hydrophobic fumed silica</td>
<td>Reinforcing agent with low thickening properties and excellent mechanical properties.</td>
</tr>
<tr>
<td>AEROSIL® R 8200</td>
<td>Liquid</td>
<td>Primary aminosilane</td>
<td>Conventional adhesion promoter – especially suitable for amine hardeners.</td>
</tr>
<tr>
<td>AEROSIL® R 9200</td>
<td>Liquid</td>
<td>Secondary aminosilane</td>
<td>Adhesion promoter – especially suitable for amine hardeners for bonding pastes. High crosslinking potential.</td>
</tr>
<tr>
<td>Dynasylan® AMMO</td>
<td>Liquid</td>
<td>Oligomeric aminosilane</td>
<td>Adhesion promoter – especially dedicated to 2K-PU and 2K-EP chemistries. Can also improve the crosslinking densities of bonding pastes and impart outstanding hydrophobicity. Innovative silane due to reduced VOC.</td>
</tr>
<tr>
<td>Dynasylan® GLYMO</td>
<td>Liquid</td>
<td>Epoxy silane</td>
<td>Adhesion promoter, can be formulated into the resin part.</td>
</tr>
</tbody>
</table>
Evonik’s silica and silanes products in wind energy applications

Wind turbine bonding pastes
Gel Coats and Top Coats
Glass Fibers
Wind turbine fundaments

Cross-section of a fiber-reinforced rotor blade

Offer for wind turbine bonding pastes
Please do not hesitate and contact us directly, if you would like to learn or discuss more about new, tailor made and innovative AEROSIL® and Dynasylan® products for windmill bonding pastes not described in this version of the brochure.
AEROSIL® R 208 –
the fumed silica for 2K-epoxy, vinyl ester and 2K-polyurethane wind turbine bonding pastes

Highly hydrophobic AEROSIL® R 208 performs excellent in various bonding paste systems and offers additional value for growing market needs. This is particular true for 2K-epoxy, 2K-polyurethane and vinyl ester systems. AEROSIL® R 208 provides an excellent thickening and thixotropic effect as well as flow limit as shown in the following examples for 2K-epoxy, vinyl ester systems and 2K-polyurethane formulations.

AEROSIL® R 208 in epoxy

Flow point:
6% fumed silica in epoxy resin, 2 weeks @ RT

AEROSIL® R 208
Competitor A
Competitor B

3-interval-time-test (structure recovery)
6% fumed silica in epoxy resin, 2 weeks @ RT

AEROSIL® R 208
Competitor A
Competitor B

AEROSIL® R 208 in vinyl ester

Flow point:
6% fumed silica in Atlac 430 (vinyl ester resin), after 4 weeks @ RT

AEROSIL® R 208
Competitor A
Competitor B

3-interval-time-test (structure recovery)
6% fumed silica in Atlac 430 (vinyl ester resin), after 4 weeks @ RT

AEROSIL® R 208
Competitor A
Competitor B

G' and G'' [Pa] →
G' = storage modulus, G'' = loss modulus

AEROSIL® R 208
Competitor A
Competitor B
Evonik’s silica and silanes products in wind energy applications

Wind turbine bonding pastes
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Wind turbine fundaments

AEROSIL® R 208 in polyurethane

6% fumed silica in epoxy resin, 2 weeks @ RT

8% fumed silica in polyol, 4 weeks @ RT

6% fumed silica in Atlac 430 (vinyl ester resin), after 4 weeks @ RT
AEROSIL® for Gel Coats and Top Coats

Coatings on wind turbine blades for on-shore or off-shore wind turbines are exposed to extreme conditions. With increasing capacity (MW), wind turbine blades are getting longer. The high tip speed of the blades leads to the crucial need of very durable coating systems to withstand harsh environmental over many years. Typical topcoats, completing the finish of the blade manufacturing, are based on polyurethanes, epoxy and unsaturated polyester resins. AEROSIL® 200 fumed silica is used as thickening agent and thixotrope for gel coats and top coats based on unsaturated polyester resins. For thickening polyurethanes, AEROSIL® R 812 S is recommended, in epoxy systems AEROSIL® R 805 improves rheology. Structure modified hydrophobic AEROSIL® R 9200 can improve the scratch resistance of coatings. AERODISP® 1030 is an easy to use dispersion based on AEROSIL® R 9200 (30 %) in methoxy-propyl acetate.

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<tr>
<td>AEROSIL® 200</td>
<td>White powder</td>
<td>Hydrophilic fumed silica</td>
<td>Thixotrope for gel coats and top coats based on unsaturated polyester resin</td>
</tr>
<tr>
<td>AEROSIL® R 812 S</td>
<td>White powder</td>
<td>Hydrophobic fumed silica</td>
<td>Thixotrope for top coats based on polyurethanes</td>
</tr>
<tr>
<td>AEROSIL® R 805</td>
<td>White powder</td>
<td>Hydrophobic fumed silica</td>
<td>Thixotrope for top coats based on epoxy systems</td>
</tr>
<tr>
<td>AEROSIL® R 9200</td>
<td>White powder</td>
<td>Hydrophobic fumed silica</td>
<td>Structure modified hydrophobic silica for scratch resistant coatings</td>
</tr>
<tr>
<td>AERODISP® 1030</td>
<td>Dispersion in methoxy-propyl acetate</td>
<td>Hydrophobic fumed silica</td>
<td>Structure modified hydrophobic silica for scratch resistant coatings</td>
</tr>
</tbody>
</table>
Evonik’s silica and silanes products in wind energy applications
Wind turbine bonding pastes
Gel Coats and Top Coats
Glass Fibers
Wind turbine fundaments
Dynasylan® for Glass Fiber

Glass fiber products, such as endless glass fibers, chopped strands, mats, rovings, yarns and milled glass fiber are used as reinforcing materials in thermoplastics and resins. Natural glass fiber shows poor adhesion to polymers, especially in the presence of moisture. For this reason, the glass surface is made organophilic by a sizing or finishing treatment. Our Dynasylan® products are essential components in sizing or finishing, which positively effect the following properties:

- transmission of glass fiber strength, to the polymer
- improvement of adhesion
- minimization of moisture sensitivity
- mechanical protection of glass fibers

Selecting the right organofunctional group of Dynasylan® silane is decisive for the bond to the polymer.

<table>
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<tr>
<td>Dynasylan® AMEO</td>
<td>Liquid</td>
<td>Aminosilane</td>
<td>*, ** PA, PU, EP, Phenolic, Melamine</td>
</tr>
<tr>
<td>Dynasylan® GLYMO</td>
<td>Liquid</td>
<td>Epoxysilane</td>
<td>*, ** EP, PU, Phenolic, Melamine</td>
</tr>
<tr>
<td>Dynasylan® MEMO</td>
<td>Liquid</td>
<td>Methacrylsilane</td>
<td>*, ** UP, Acrylic</td>
</tr>
<tr>
<td>Dynasylan® 2201 EQ</td>
<td>Liquid</td>
<td>Ureidosilane</td>
<td>PA, Phenolic</td>
</tr>
<tr>
<td>Dynasylan® 1189</td>
<td>Liquid</td>
<td>Sec. Aminosilane</td>
<td>PP, PA</td>
</tr>
<tr>
<td>Dynasylan® SIVO 214</td>
<td>Liquid</td>
<td>Proprietary aminosilane composition</td>
<td>PP, PA, Phenolic</td>
</tr>
<tr>
<td>Dynasylan® 1175</td>
<td>Liquid</td>
<td>Cationic aminosilane</td>
<td>PA, EP, Phenolic</td>
</tr>
<tr>
<td>Dynasylan® HYDROSIL 1151</td>
<td>Liquid</td>
<td>VOC free water borne silane system</td>
<td>PA, PU, EP, Phenolic</td>
</tr>
</tbody>
</table>

* Important component in glass fiber sizes
** adhesion promoter for (selection): PA = polyamide, PU = polyurethane, EP = epoxy resin, UP = unsaturated polyester, PP = polypropylene
Evonik’s silica and silanes products in wind energy applications
Wind turbine bonding pastes
Gel Coats and Top Coats
Glass Fibers
Wind turbine fundaments
Protectosil® to protect wind turbine fundaments

Due to the special design of wind turbines – a high tower usually built in an area of strong winds – the concrete fundaments of such constructions have to bear very high loads. Concrete will eventually crack under such conditions\(^1\) and cracking will lead to further deterioration due to e. g. corrosion of reinforcement, alkali-silica-reaction or freeze/thaw damage, thus posing a threat to the structural integrity and safety of the whole construction.

Protectosil® BHN, Protectosil® CIT and Protectosil® DRY CIT are very efficient products to protect new and even already cracked concrete. Protectosil® BHN, being a water repellent impregnation, as well as Protectosil® CIT and DRY CIT, stopping and protecting from corrosion, have been shown to successfully protect concrete for decades wherever they are applied. Calculations have shown that the cost for the repair of concrete structures can be cut by up to 98 % when using Protectosil® products.\(^2\) Of course, Protectosil® products are tested and controlled according to the latest building standards available, such as EN 1504-2.


\(^2\) Ch. Haag „Der ökologische Break Even“ in R. Baumann, F. Wittmann (Hrsg.), Technologie, Ökonomie und Ökologie, Herausforderungen an die moderne Bauchemie, Aedificatio Verlag Freiburg, 2002.

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<tr>
<td>Protectosil® CIT</td>
<td>Colorless liquid</td>
<td>modified alkylsilane</td>
<td>ready-to-use impregnation to prevent and to stop chloride induced corrosion in steel reinforced concrete, to be applied on cured concrete surfaces</td>
</tr>
<tr>
<td>Protectosil® DRY CIT</td>
<td>White powder</td>
<td>polymer blend based on alkysiloxane</td>
<td>corrosion protection system to be mixed into cementitious mixes, to prevent chloride induced corrosion of new concrete structures</td>
</tr>
<tr>
<td>Protectosil® BHN</td>
<td>Colorless liquid</td>
<td>monomeric alkylsilane</td>
<td>water repellent impregnation according to EN 1504-2 to prevent water uptake and uptake of water soluble aggressive pollutants, to be applied on cured concrete surfaces</td>
</tr>
<tr>
<td>Protectosil® 850</td>
<td>White powder</td>
<td>polymer blend based on alkysiloxane</td>
<td>water repellent to be mixed into cementitious mixes, to prevent water uptake and uptake of water soluble aggressive pollutants, tested according to EN 934-2</td>
</tr>
</tbody>
</table>
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