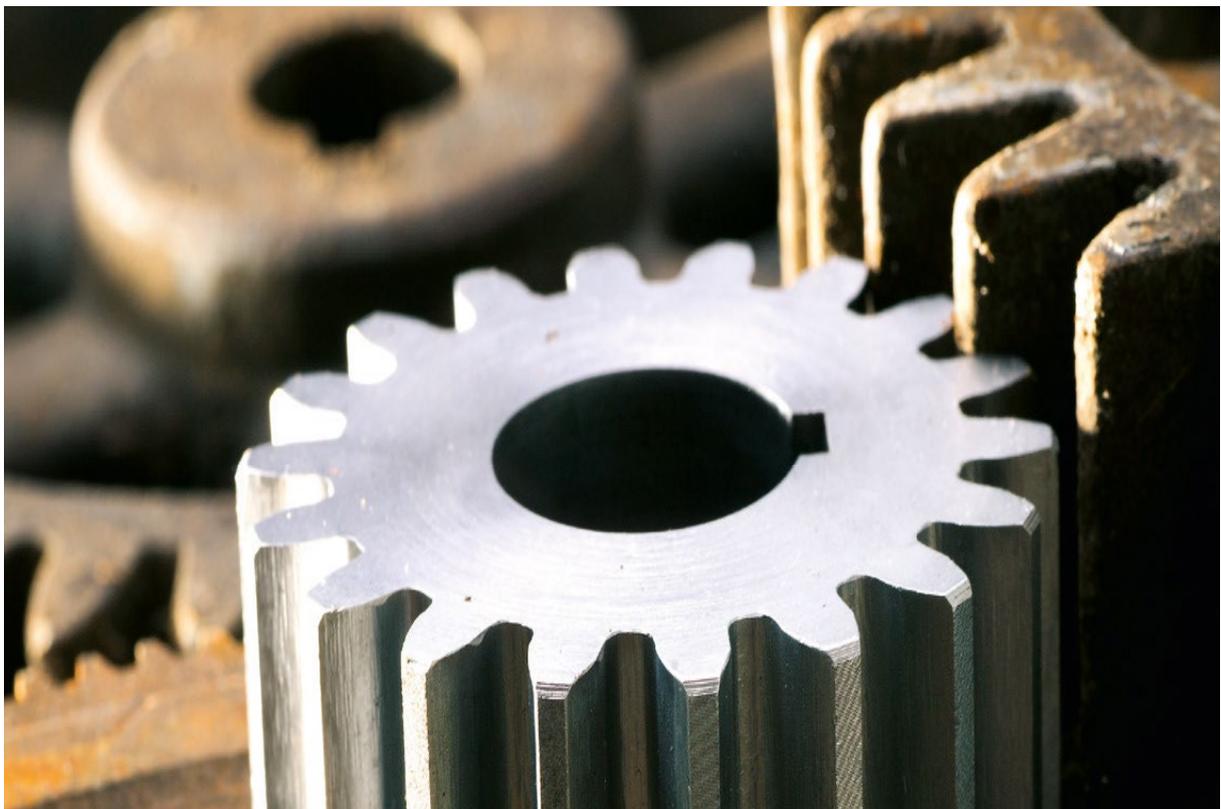


Dynasylan® for Metal Treatment




Dynasylan®

 **EVONIK**
POWER TO CREATE



Dynasylan® by Evonik – There Is No Better Guarantee for Quality and Value

For more than 50 years, we have been manufacturing products for paints and coatings, and today Evonik is one of the largest and most experienced chemical suppliers to the paint and coatings industry worldwide. It comes from a commitment to research that has translated into numerous patents and new technologies that keep us and our customers at the cut-

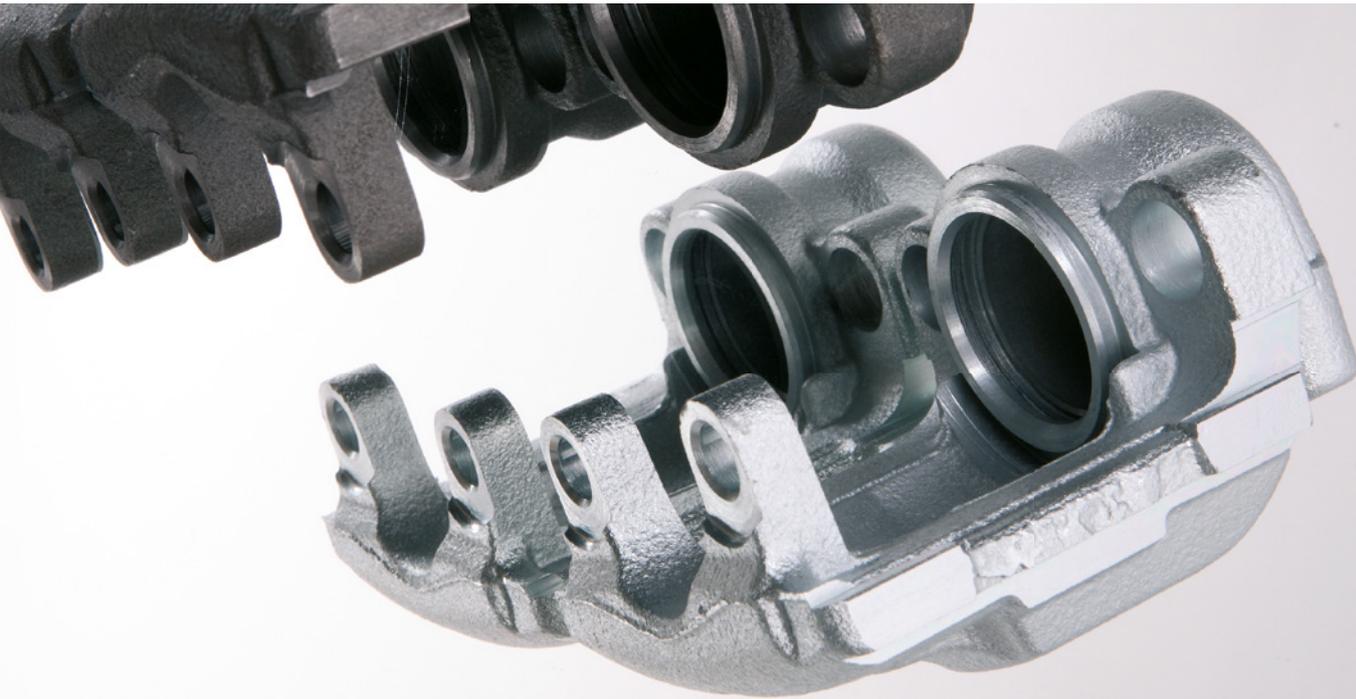
ting edge – not just in terms of optimizing processes and keeping production costs down, but also by opening new application areas. And it comes from our dedication to quality, reliability and a partnership approach. That is how Dynasylan® has become the leading global brand for functional silanes.



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Dynasylan® for Metal Treatment

The Dynasylan® product family covers all the bases when it comes to metal protection. Here, our inorganic resins and water-borne silane systems are used in new and much more effective, environmentally friendly metal treatment formulations, either as additives or as a platform for silane-based metal treatment final products. In addition, Evonik's Multifunctional Silane Systems™ combine a number of chemical functions in a single solution. The result: improved performance, lower complexity, simplified processing, and lower storage costs. Our broad product spectrum offers the perfect solution to most challenges in metal pre-treatment: A wide range of water-borne silane systems designed for outstanding formula-

tion stability to address the customer's various substrate types and specifications. Customized Multifunctional Silane Systems™ offer further potential for formulation optimization. Here, standard silanes can easily be replaced by the newer, more convenient and simpler Multifunctional Silane Systems™. Having the widest range of sol-gel raw materials to choose from also means that both, VOC-containing raw materials for special applications and purely water-based specialty products are available in commercial quantities on the metric-ton scale. No other company can offer this combination from a single source.

Where Dynasylan® Makes the Difference

Effective corrosion protection is crucial not only from a safety standpoint. A study commissioned by the Dechema Society for Chemical Engineering and Biotechnology shows that 4 percent of the GNP of industrialized countries are lost to corrosion each year. Prevention in the form of proper protection against corrosion from exposure to the elements or other agents is the only answer here, be it for a bridge, a building, an automobile, or an electronic component.

Although conventional surface pretreatment processes – mainly chromatinization and phosphatization – are relatively inexpensive, they entail much greater environmental costs due to the aggressive media they use. Processes involving chromium (VI) are especially problematic. Regulators are already addressing the issue and the RoHS requirement (Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment). For instance, rules now preclude the use of chromatinization processes based on chromium (VI) in many industries. Here, silane based systems offer a compelling alternative.

Formulating a metal protection system is complicated. Commonly such systems are very thin and still show excellent corrosion protection. The substrates can vary in the type of metal or even alloy as well as

the type of surface. Furthermore, the performance requirements, exposure to corroding influences, application techniques are very different and commonly require separate metal treatment systems. For such a variety of needs Evonik has a large range of products, each displaying different functionalities, pH-values, compatibilities, and thus provide an excellent toolkit for metal protection formulations.

Dynasylan® can be used to formulate in water-borne as well as solvent based systems with an excellent storage and bath stability. A large range of formulations in different pH-ranges and different ingredients can be used in conjunction with Dynasylan® silane systems.

Dynasylan® silanes are currently used successfully in several metal corrosion protection technologies. A large variety of applications benefits from their use:

- Electroplating
- Galvanizing
- Coil and Sheet Coatings
- Powder Coatings
- Automotive Supplies
- Finishing Sealers
- City Furniture
- Appliances
- Aerospace
- Fasteners
- Construction

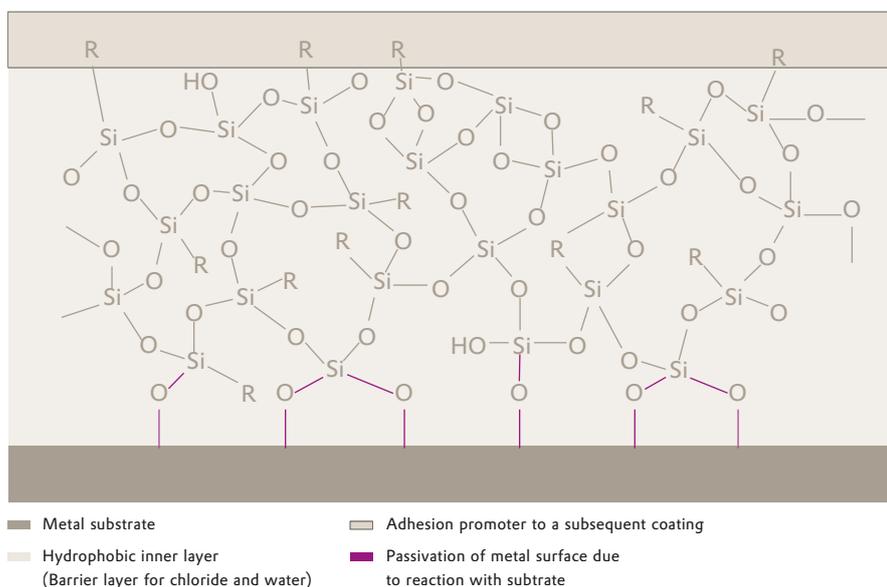


Silanes for Metal Pre-Treatment

As the world's largest manufacturer of silanes, Evonik offers decades of experience in silane chemistry. A key reaction in the use of organofunctional silanes for surface modification is hydrolysis, which generates silanols. Silanols are extremely reactive and work with a broad typology of inorganic surfaces. Here, the silane molecules bind chemically onto the sur-

face and permanently modify it, delivering the following benefits:

- Excellent adhesion to the metal surface
- Surface passivation via reaction of the silane with the metal surface
- Formation of a hydrophobic protection layer
- Adhesion to the next layer via reaction with a subsequent coating



Today, solvent-based silane systems are technically demanding in their application and have so far conquered only niche applications in the metal protection industry: they are primarily used wherever durable corrosion protection is required and other coatings have reached their limits – for example, on the metal parts of brid-

es, ships, docks, and oil rigs. They offer significant resistance to exposure and, by acting as a barrier to salt and water also improve the adhesion of additional layers. However, they contain a large quantity of organic solvents and thus no longer meet most VOC (Volatile Organic Compounds) regulatory requirements.

Setting Standards: Dynasylan®

While adhesion, passivation of the metal surface, and hydrophobation remain the most important requirements in the formulation of silane-based metal treatment systems, other aspects are becoming increasingly important. For example, silane-based materials or technologies must be capable of being integrated into existing metal treatment formulations and must have the lowest possible solvent content to meeting increasingly stringent VOC regulations. In other words, advanced products must possess a range of functionalities.

It is for these advanced systems that Evonik has developed Multifunctional Silane Systems™, which combine a variety of functions in a single product. One of the most successful examples is the Dynasylan® HYDROSIL product family. These water-based silanes, which have already set new standards for combining high reactivity with outstanding storage stability, are now being supplemented by the latest generation of Multifunctional Silane Systems™: the Dynasylan® SIVO series, the first water-based modularly structured sol-gel system.

More than an Environmental Bonus

Corrosion protection requirements vary depending on environmental conditions, application technology, and final use. The same goes for testing requirements, be it in the construction, automotive or consumer products industries. Our silane-based solutions offer unrivaled flexibility in addressing the most diverse issues, and can often be added to existing formulations – from primers to thicker sol-gel coating systems.

Our Multifunctional Silane Systems™ are designed for a broad application spectrum on most metal surfaces, including aluminum, steel, zinc and phosphatized as well as other treated metal surfaces. They also deliver significant advantages in terms of processing and waste disposal. Other

systems that use heavy metal, for instance, create problems due to regulations and very complex and costly waste management. In simplifying the treatment process, our new silane-based solutions also help reduce costs by, for example, eliminating a rinsing step after silane application.

All our water-borne Multifunctional Silane Systems™ feature the following benefits:

- Chrome-free
- Heavy metal-free
- Odorless
- Fluoride-free
- UV-stable
- Highly reactive

The Right Dynasylan® for Your Formulation Needs

Dynasylan® HYDROSIL

These hydrolyzed multifunctional silane oligomers ensure adhesion to the substrate, provide barrier protection as well as adhesion promotion for subsequent topcoats. They can thus be used either as an additive to formulations or as an adhesion promotion primer. In combination with an appropriate coating they form an effective protection system against corrosion.

...for improved adhesion

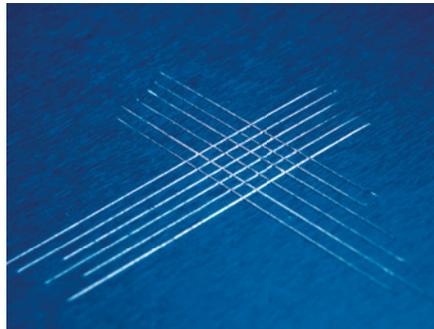
Promoting adhesion is a key application for Dynasylan® HYDROSIL because it provides an excellent bridge from the inorganic substrate to the next coating layer. Usually about 0.5-3% of Dynasylan® HYDROSIL in an aqueous or alcoholic solution will deliver excellent adhesion (especially wet adhesion) for various different kinds of water-borne and solvent-based coatings on aluminum, steel and glass, especially under moist conditions.

Figures:

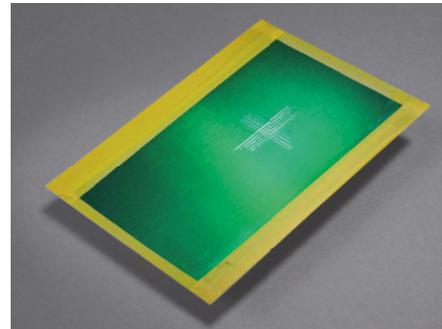
Aluminum substrate with a colored (Halizarine green) latex paint. Adhesion after 24 hours in a water bath.

Figures:

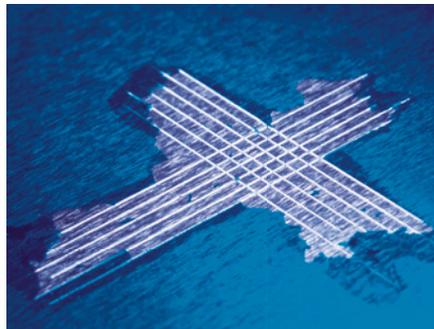
Aluminum substrate with a colored (Halizarine green) latex paint. Results after 500 hours in a Q-UV chamber after exposure to wet-dry cycles (100 min dry, 18 min rain).



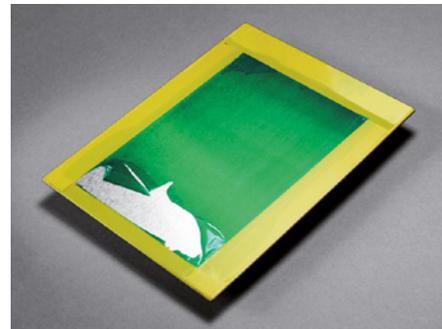
With Dynasylan® HYDROSIL 2909 primer



With primer containing Dynasylan® HYDROSIL 2909



Without primer



Without Dynasylan®

...for improved corrosion protection

The corrosion protection properties are equal or better than traditional pretreatment systems, e.g., iron or zinc phosphate and chromate – with the added environmental and process simplification benefits. Results according to ASTM B117 are shown in the chart on the opposite page. Dynasylan® HYDROSIL can be applied directly on clean bare-metal surfaces.

The application of a water-borne polysiloxane does not require as many steps as traditional pre-treatments, which improves the efficiency of the process and leads to significant cost savings. The thickness of such a Dynasylan® HYDROSIL layer (1 µm or less) is considerably thinner than with traditional pre-treatment systems.

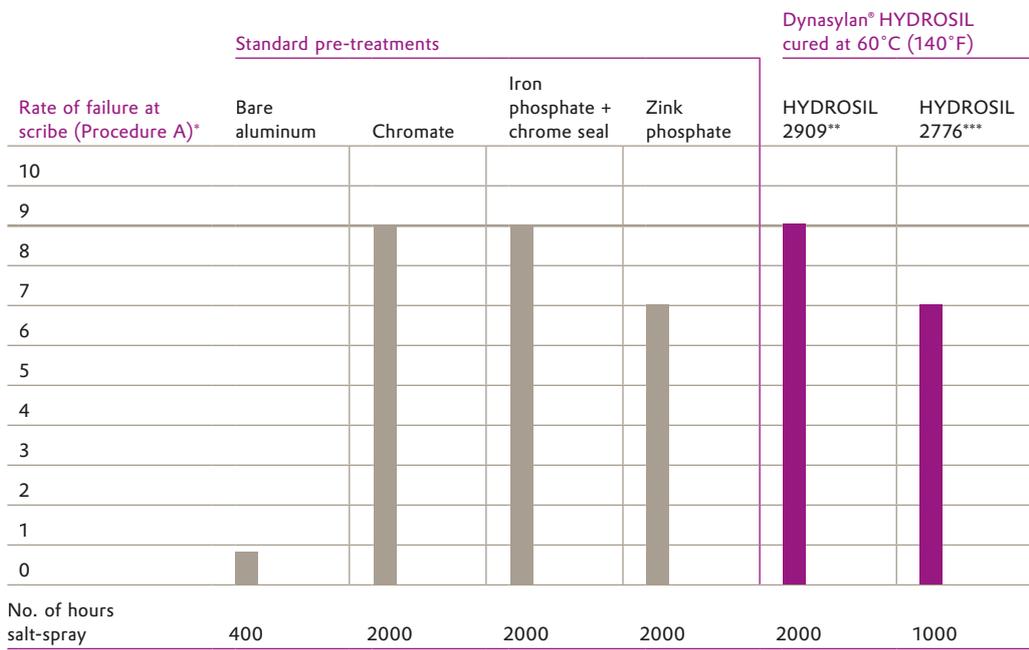


Extensive testing for durability and flexibility shows no resulting cracks, breaks or deterioration of the paint or metal surfaces on panels pre-treated with Dynasylan® HYDROSIL and SIVO® SOL Technology.



Here, aluminum and steel metal panels are continuously examined after salt spray testing and compared over a period of 500-2000 hours for any corrosive deterioration or defects on the metal surface. Advantage: Dynasylan® HYDROSIL.

Comparison of standard pre-treatments against Dynasylan® HYDROSIL pre-treatments
Corrosion test ASTM B117 on pre-treated ALU 6061



*ASTM D1654-05 Procedure A **5% in DI Water ***25% in DI Water

Dynasylan® SIVO – the Modular System for Metal Protection

The base component Dynasylan® SIVO 110 is an inorganic particle containing a siloxane oligomer derived from Evonik’s advanced sol-gel technology. Sol-gel technology is a hydrolysis and condensation method that allows formation of stable oligomeric silane structures. The result is a completely new inorganic binder that can be used in a large number of applications, from transparent oleophobic inorganic topcoats to corrosion protection systems. Virtually VOC-free and designed for extended shelf life, it provides an effective platform for various additives. While Dynasylan® SIVO 110 can be used by itself; other additives can be added either separately or in combination, depending on the properties required. Dynasylan® SIVO 111, for instance, works as a neutralizing agent for formulations to be applied on steel. Dynasylan® SIVO 112

is a hydro and oleophobic additive that allows for the formulation of low energy topcoats. And Dynasylan® SIVO 113 is a hydrophobizing additive that can be used to significantly increase coating weatherability.

This innovative technological platform is a first insofar as it allows coating formulators to fully customize their inorganic coatings. Metal pre-treatment formulations based on Multifunctional Silane Systems™ can replace chromium-containing metal pre-treatment systems. They are suitable for a multitude of substrates, application processes, and can be applied with existing processing equipment. Sand blasted steel, where zinc treatment raises environmental issues and white rust is a problem, is just one dedicated candidate for the Dynasylan® SIVO technology.

Dynasylan® SIVO 110

Dynasylan® SIVO 110 is an inorganic resin and the platform of the first modular sol-gel system of the Dynasylan® SIVO series. It is a water-borne inorganic binder that includes inorganic particles with a narrow particle size distribution and is derived from the successful Dynasylan® HYDROSIL product family. It is ideal for the formulation of inorganic coating systems as well as corrosion protection primers. Dynasylan® SIVO 110 represents the “backbone” of the series, from which formulations with various functions are derived through formulation with different additives. The additives, listed below, allow formulating stable, but still highly reactive, coating systems.

Dynasylan® SIVO 111

Dynasylan® SIVO 111 is used as an additive to regulate the pH-value of Dynasylan® SIVO 110 or to neutralize it. Neutral or mildly basic coating formulations are required in many applications, but the pH-value cannot just be adjusted by means of “simple” (i.e., salt-forming) neutralization reagents, as this would later negatively impact corrosion protection. Dynasylan® SIVO 111, by contrast, allows for the protective and effective neutralization of the overall system. It often improves corrosion protection properties in the process.

Dynasylan® SIVO 112

As an additive, Dynasylan® SIVO 112 allows the formulation of coatings that are simultaneously oil and water repellent – with easy-to-clean properties – and therefore show improved corrosion protection. As a water-based component, Dynasylan® SIVO 112 is ideally suited for incorporation into the overall sol-gel system of the Dynasylan® SIVO series, which is also water-based.

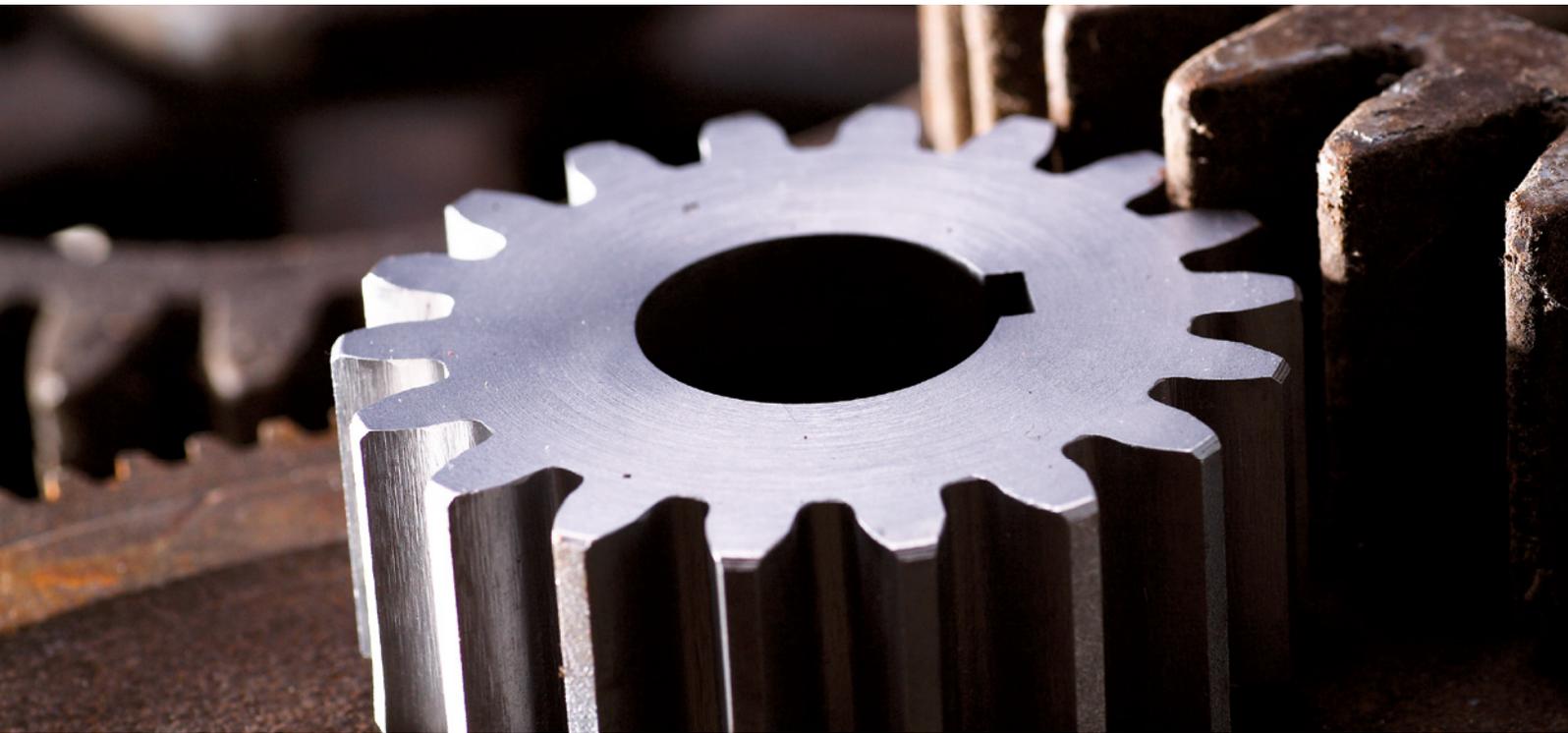
Dynasylan® SIVO 113

Dynasylan® SIVO 113 is indicated in formulations that place a premium on the water repellent properties of a coating film as it effectively establishes and reinforces hydrophobic properties. If it is added to the Dynasylan® SIVO 110 base component, the subsequent coating film will develop water repellent properties. This is especially advantageous in exterior applications and on metals, where resistance to weather exposure is significant.

The table shows recommended amounts of each of the additives that can be formulated with Dynasylan® SIVO 110.

The SIVO® SOL Technology System

Product	Description	Typical amount added (approximate values)
Dynasylan® SIVO 110	Base module	—
Dynasylan® SIVO 111	Neutralization agent	2-4%
Dynasylan® SIVO 112	Oleophobic additive	10-50%
Dynasylan® SIVO 113	Hydrophobic additive	5-10%

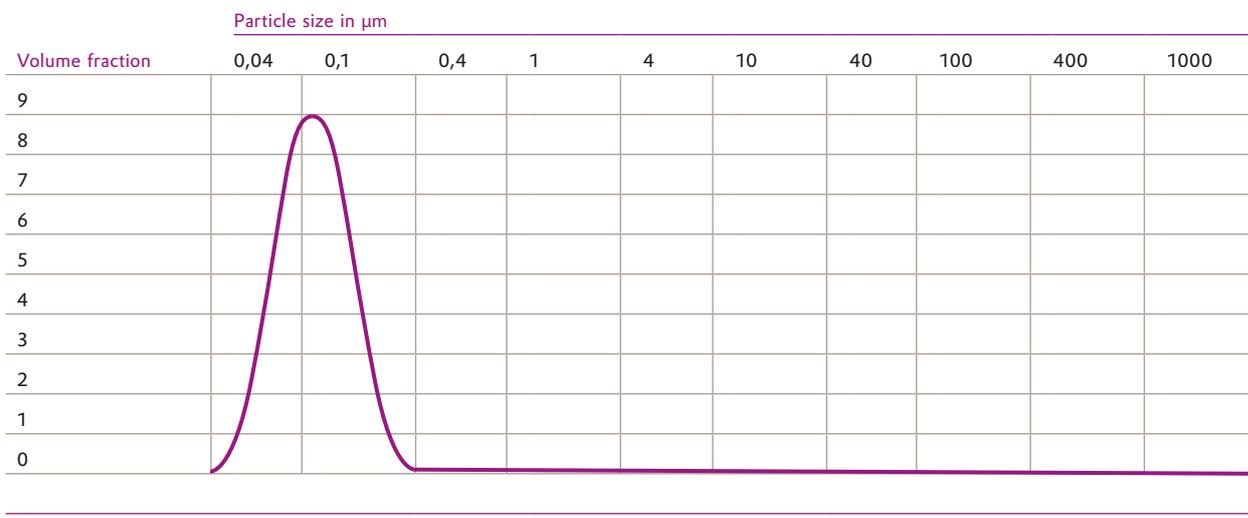


Dynasylan® SIVO 110: An Inorganic Resin

Dynasylan® SIVO 110 is a water-borne silane based binder with silane modified inorganic particles. A tight particle size distribution allows for the formulation of a wide range of coating systems. Upon curing, these coatings form a closed film that provides an excellent barrier to water and chloride. This system has been optimized

for extended shelf life, excellent film forming properties, and superior formulation possibilities. Especially the long shelf life is extraordinary for a water-borne sol-gel system. Dynasylan® SIVO 110 is the ideal starting point for water-borne sol-gel coatings and metal pre-treatment system.

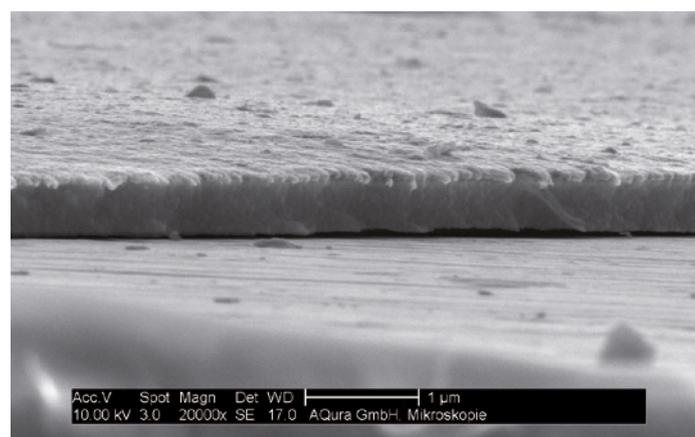
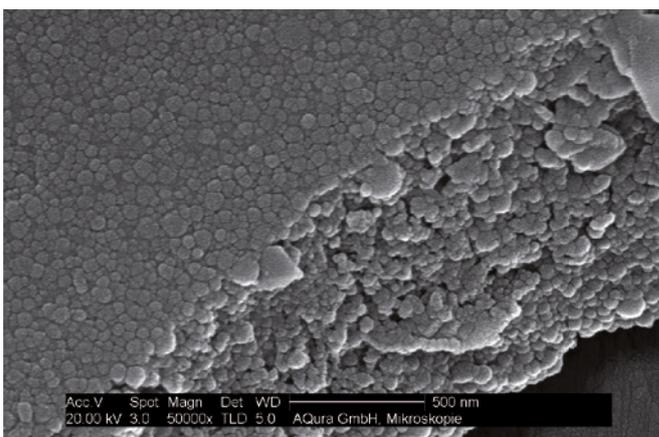
Particle size distribution of Dynasylan® SIVO 110



Particle size distribution of the water-borne Dynasylan® SIVO 110 inorganic resin.



In the pictures below, a formulation with Dynasylan® SIVO 110 was applied onto an aluminum panel. The scanning electron microscope images show the dense inorganic particle network formed by the silane binder.





Corrosion Protection with SIVO® SOL Technology

SIVO® SOL Technology is designed for use with thermally cured coating systems, e. g. powder coatings, which are normally cured at temperatures of approximately

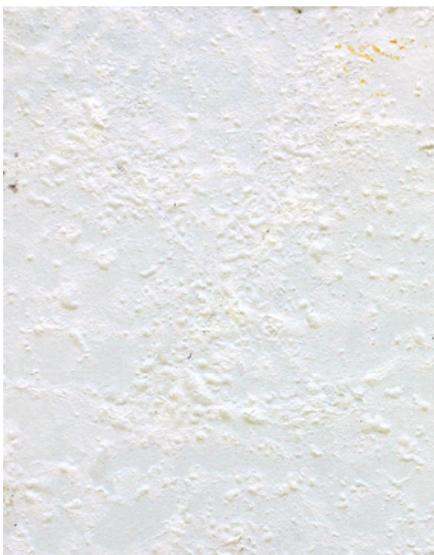
200 °C. Here, the system is cured together with the powder coating and as a result precludes the formation of white rust that is common with zinc treated steel.





Shown here: Improved primer adhesion using SIVO® SOL Technology, which is at the heart of the Dynasylan® SIVO product family. The panels were sand blasted steel pre-treated with a conventional organic primer or SIVO® SOL Technology.

The polyester powder coating was cured 10 minutes at 200 °C. The 500 hour salt spray test shows white rust formation below a conventional organic primer: SIVO® SOL Technology allows for a thinner film and delivers better results.



Steel panel with a standard organic primer (5 μm). Powder coating cured at 200 °C, 10 minutes.



Steel panel with SIVO® SOL Technology < 1 μm Film thickness. Powder coating cured at 200 °C, 10 minutes.



Dynasylan® SIVO 160 – a New Multifunctional Silane System™

Dynasylan® SIVO 160 is the latest addition to the range of silanes for corrosion protection. Designed as a corrosion protection primer specifically for zinc, aluminum, and magnesium, Dynasylan® SIVO 160 sets new performance standards with a low curing temperature for efficient coupling to the metal surface. Furthermore, a lower concentration is required in order to achieve effective corrosion protection.

Dynasylan® SIVO 160

Dynasylan® SIVO 160 is a water-borne silane system based on sol-gel technology designed for metal surface finishing. This storage stable system is ideal for the addition to already existing or the creation of new environmentally friendly metal protection formulations. Besides offering all the advantages of condensed reactive silanes, it contains neither heavy metals nor fluorides and reacts easily with metal surfaces. In addition, its condensed nature ensures superior wetting of the metal surface and less need to formulate wetting agents into the system. Such wetting

agents often reduce the effectivity of the corrosion protection system. Its high reactivity, demonstrated by a remarkably low curing temperature of 60 °C, represents a major breakthrough for water-borne sol-gel systems.

The system has been especially developed for aluminum and magnesium substrates, and can be formulated into acidic corrosion protection systems to achieve a marked improvement in corrosion protection performance.

More importantly, the performance of the Dynasylan® SIVO 160 system on aluminum is on a par with chromium systems. In the example on the next page, silane-treated aluminum panels that are coated with a liquid epoxy coating favorably to hexafluorotitanic acid or chromate treated systems. In the second example aluminum is treated with Dynasylan® SIVO 160 system and coated with a polyester powder coating. The reference is chromated aluminum coated with a polyester coating.

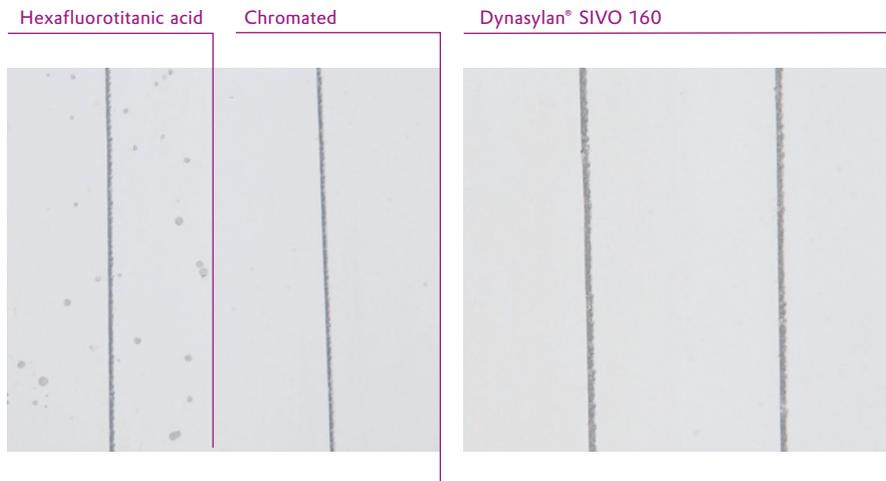
Example Application

2-Pack epoxy coating

Epoxy coatings are especially important as primers. The pre-treatment system can markedly increase the service life of the final product. Thus Dynasylan® SIVO 160 can optimize pre-treatment formulations for complex layer compositions. Shown below are panels that were cleaned with

an alkaline industrial cleaner. Dynasylan® SIVO 160 was applied in a concentration of 0.3 % solid content and dried at 60 °C for 10 minutes. The panels were then coated with a 50 µm (wet coating thickness) of a standard 2-pack epoxy primer.

Reference



500 hours of acetic acid salt spray testing.
Especially adhesion and corrosion at the scribe are improved in comparison to traditional corrosion protection systems.

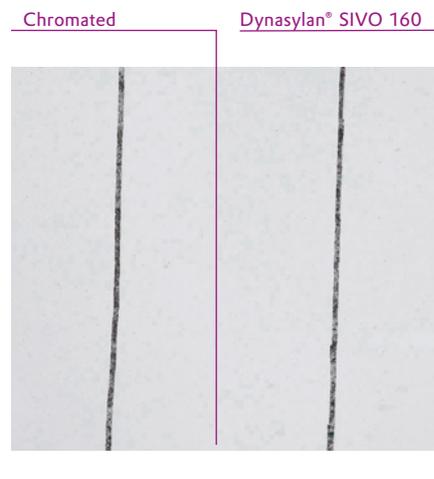
Polyester powder coating

Due to environmental factors powder coatings need to cure at ever lower temperatures. Dynasylan® SIVO 160 is an excellent starting point for such new low-temperature curing coatings.

Further example, the aluminum substrates were treated with Dynasylan® SIVO 160 and a polyester powder coating was applied. The system was cured at 180 °C, and then exposed to 240 hours of copper accelerated salt spray test.

Furthermore, Dynasylan® SIVO 160 is excellent for the pre-treatment of metals before a low-temperature (120 to 140 °C) curing reactive powder coating.

Salt spray test

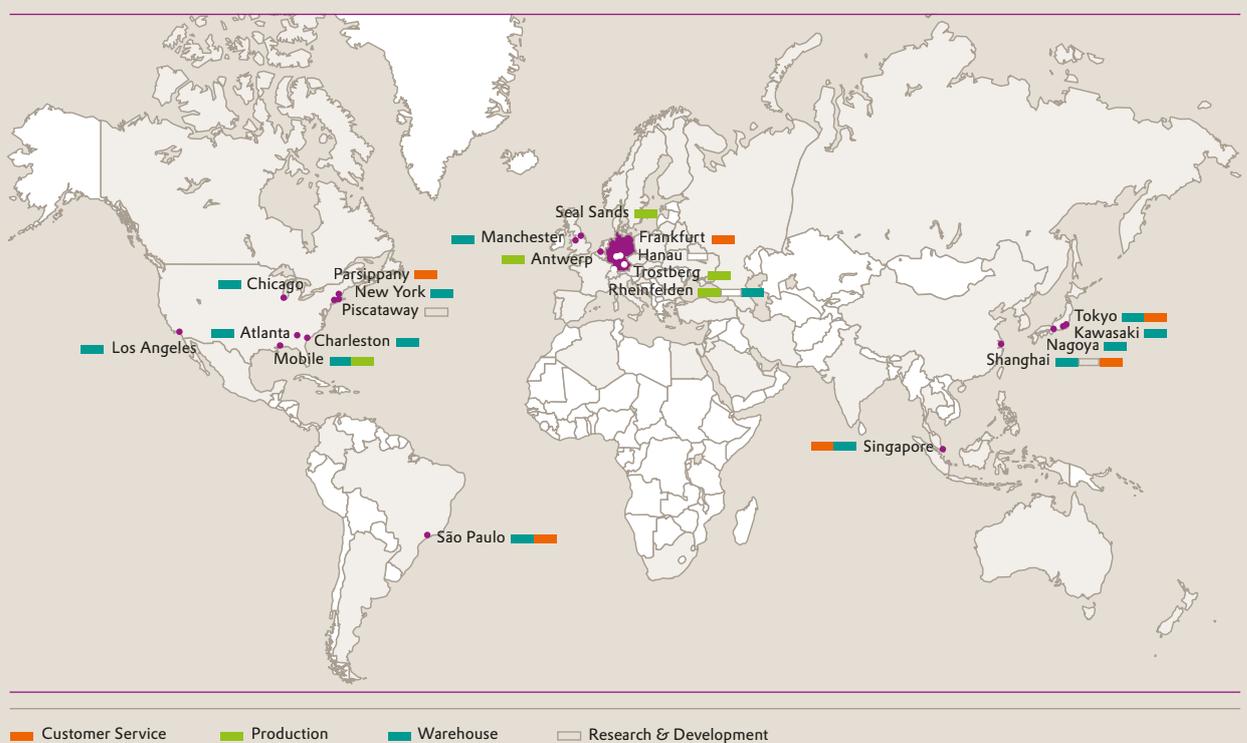


240 hours copper accelerated salt spray test.

Suggested silanes for different substrates

Substrate	Pretreatment with Dynasylan®	Coating	Curing temperature (°C)	Benefits
Sand blasted steel	SIVO 110 + SIVO 111	Polyester powder coating	200	Improved durability and corrosion resistance
Hot dip galvanized steel	SIVO 110 + Acrylic Dispersion	Polyester powder coating	200	Improved durability and better adhesion
Aluminum 6061	HYDROSIL 2909 5% in DI water	2-pack PU (solvent based)	60	Excellent corrosion protection
Electro galvanized steel	HYDROSIL 2909 5% in DI water	2-pack PU (solvent based)	60	Excellent corrosion protection
Cold rolled steel	HYDROSIL 2909 5% in DI water	2-pack PU (solvent based)	60	Excellent corrosion protection
Aluminum	SIVO 160 1 % in DI water	2-pack epoxy primer (solvent based)	60	Excellent corrosion protection, equal to chromate
Aluminum	SIVO 160 1 % in DI water	Reactive PU powder coating	140	Excellent corrosion protection, similar to chromate

Applications, demands on corrosion protection and subsequent top-coats all differ, thus for best effects, Dynasylan® provides a range of water-borne silanes for such a wide range of applications.



Dynasylan® is there for you. Wherever you are, wherever your production is, we can deliver silanes.

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