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Opening photo: Whether on utility poles, expressways, bridges, buildings, water lines, or pipelines, corrosion is all around us.



INNOVATIONS: PRESENT&FUTURE

No Chance For Rust

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Specialists of Evonik's Resource Efficiency Segment have developed novel silane-based corrosion inhibitors that are particularly eco-friendly, easily applied, and extraordinarily efficient. Corrosion gnaws its way stealthily through

bridges, machines, and buildings, whether of metal, concrete, glass, or plastic; in all of these materials it is a serious problem (**ref. Opening photo**). As long as six years ago, DECHEMA, the Society for Chemical Engineering and Biotechnology, estimated

annual global losses due to corrosion at an astounding US\$ 3.3 trillion. So corrosion is a drain on the wallet as well as on the surfaces of materials. Industrialized countries lose about three percent of their gross domestic product to corrosion each year. But according

to DECHEMA, appropriate protective measures could save up to 30 percent of these costs, amounting to approximately US\$ 1 trillion every year.

These figures clearly indicate that today corrosion protection is an issue that cannot be ignored. Nonetheless, established methods of surface treatment, including chromating and phosphating, are increasingly coming up against limitations and are seen ever more critically, mainly for reasons of environmental protection. Application techniques for substances containing chromium (VI) are particularly problematic. The use of these substances is being banned in Europe in an increasing number of applications, through such provisions as the second RoHS Directive (Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment), which came into force in 2013. The US, Japan, China, and South Korea have adopted similar regulations.

Alternative methods for protecting metal surfaces against corrosion are therefore urgently needed, and these methods

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must be eco-friendly as well as reliable. Evonik’s developers rely here on hydrolyzed and condensed silanes that form a binder: the formulation of such binders results in eco-friendly corrosion protection systems. During the curing process a protective film with a thickness in the nanometer to micrometer range is formed; although thin, the film is highly impervious and protects the underlying metal against water and corrosive substances. It can be formulated using other binders and fillers to form thicker corrosion protection systems. In recent years, Evonik’s specialists have developed, under the Dynasylan® SIVO brand name, a series of binders that have proved their worth in a very wide range of materials and application methods.

Environmentally friendly zinc dust paints

Paints with an underlying zinc dust primer are the means of choice when long-term corrosion protection is called for and other coatings have reached the limits of their capabilities. Typical application areas include transmission towers, industrial plants, bridges, and shipbuilding. The zinc dust in the paint is deposited as a fine film on the surface of the materials, the particle density being so high that the individual metal particles are in contact with one another. The electrically conducting film so formed then serves as anodic

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Figure 1: Corrosion inhibition primers based on Dynasylan® SIVO 160 are particularly suitable for protecting materials like aluminum, magnesium, and zinc-galvanized iron or steel against corrosion.

corrosion protection. The current difficulty is that zinc dust paints have often used inorganic binders with high solvent content, which release volatile organic compounds while curing. This is seen increasingly critically on the grounds of health and safety. Water-based zinc dust paints, on the other hand, are normally formulated with epoxy which do not tolerate excessive heat or UV radiation.

The water-based Dynasylan® SIVO 140 binder developed by Evonik's researchers combines the best of both worlds. Like the solvent-based inorganic binders, it is powerful and thermally stable. But it releases almost no volatile organic substances and is therefore as environmentally friendly as the water-based zinc dust paints. Dynasylan® SIVO 140 was designed especially for use in two-pack zinc dust paints. It is formulated with the zinc dust as the second component and then cures at normal ambient temperatures. The organic-inorganic binder can easily be diluted with water without the generation of undesired ethanol; in addition, the active silanol groups are stabilized, ensuring

optimal miscibility with fillers and pigments. Formulations can be adjusted for high or low dry film thicknesses, depending on the area of application.

When passivation alone isn't enough

When metals rust, an oxide film forms on the surface. This familiar iron oxide (rust) film is porous. As a result, corrosion penetrates even deeper into the metal. Many other metallic materials such as aluminum, zinc, and magnesium behave differently, interacting with air on the surface to spontaneously form an oxide film that, although thin, is impermeable to air. This passivation protects the underlying material from contact with oxygen and thus from further degradation.

It may nevertheless be necessary to provide even these metals with additional corrosion protection if, for example, they come into contact with chloride.

Corrosion inhibition primers based on Dynasylan® SIVO 160 are particularly suitable for protecting materials like aluminum, magnesium, and zinc-galvanized iron or steel against corrosion (Fig. 1). In contrast to the current solutions employed in this area, the binder contains neither heavy metals nor fluorides, which are highly objectionable from an environmental viewpoint.

These additives are also not required in the formulation of the actual rust inhibition primer. A film thickness of just 100 to 200 nanometers of this water-based silane system is all that is needed to protect aluminum from further corrosion. For use in exterior applications, the system is formulated with additional additives and stabilizers. Thanks to the high reactivity of the organofunctional silanol groups, curing can take place at temperatures as low as 60°C.

Longer service life of structures and installations

Dynasylan® based corrosion control coatings have been tried and tested over many years—in Basel's Picasso Center, for example, and London's "Gherkin" office tower, as well as in protective paints on innumerable bridges and ships all over the world. In all these areas Dynasylan® SIVO offers a double benefit for the environment: directly, by releasing fewer volatile organic compounds, and also by increasing the service life of structures and installations as a result of its corrosion-inhibiting action. This prevents waste and represents a genuine contribution to sustainability. ○



Corrosion as a cost factor

3.3 trillion US\$: global losses estimated by DECHEMA due to corrosion six years ago;
990 billion US\$ per year: global potential savings from using existing technology to reduce corrosion; Industrialized countries lose about **3%** of their gross domestic product to corrosion.

