WATER-BORNE SOL-GEL BASED BINDERS FOR THE FORMULATION OF AMBIENT CURING ZINC DUST PAINTS

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Introduction

Regulatory pressure and increasing environmental awareness bring are reducing the desirability of VOC containing paints and coatings and cause an increase in interest in water-borne systems. In the year 2011 over half of the total coating consumption in the world was based on water-borne systems. Quality, robustness and performance of water-borne coatings are getting better and new coating developments are mainly done with water-borne systems.

Zinc dust paints are well known in the field of heavy corrosion protection. Standard silicic acid ester based zinc silicate coatings are solvent-borne and are applied on sand blasted steel blast steel. Such paints are available as one- and two-pack systems. One-pack systems cure in a matter of hours and days by humidity hydrolyzing the silicic acid ester allowing condensation to take place. One-pack systems such as Dynasylan® MKS are stable for at least half a year when formulated and cured with the help of ambient moisture at room temperature after application. Zinc rich paints based on inorganic binders do have a good chemical resistance, heat resistance, and UV stability. The advantages of inorganic binders like silicic acid esters are obvious but formulations based on these inorganic binders still contain significant amounts of organic solvents.

Water-borne zinc rich paints based on silicates have been known for a long time. Silicate binders are alkaline and zinc coatings based on these have good corrosion protection properties. However, the surface of the cured zinc paint can remain alkaline and the next coat, often an epoxy coating, can be damaged at the interface. Delamination of the top coat frequently occurs. Also, water-borne zinc rich paints based on organic binders (such as epoxy) are entering the market. The main disadvantage of such systems is the limited heat resistance and weather stability.
A new water-borne binder for zinc silicates

A new water-borne organic-inorganic binder system for two-pack zinc rich paints is now available on the market. Zinc rich paints based on this novel binder are nearly VOC-free, heat resistant and cure at ambient temperature. The binder is called Dynasylan® SIVO 140 and is an improvement for the environment almost zero organic solvent is emitted to the atmosphere.

Dynasylan® SIVO 140 is silane based, fully hydrolysed, can be thinned with water or solvents and is almost VOC-free. The active silanol groups are stabilized and the system can be formulated with fillers and pigments such as zinc and zinc oxide resulting in a corrosion resistant protective coating. The pot life of such a formulation depends on the filler type and filler concentration but typical is typically 7 hours. The formulation based on Dynasylan® SIVO 140 can be applied on a clean iron or steel surface. Alkaline cleaning can be done on production lines but outdoors an abrasive sand blasted the iron/steel surface is necessary. Depending on the formulation, Dynasylan® SIVO 140 systems can be sprayed or brushed.

Formulations

A typical formulation is described in Figure 1. It contains large amounts of zinc and zinc oxide and shows how such formulations can be formulated using large amounts of solids and a low binder content.

![Figure 1: Typical formulation for zinc silicate coating based on Dynasylan SIVO 140. High solid content compared to binder content.](image)

The drying time after application of the paint is an important criterion for processing. The drying time (time to touch-dry) depends on several parameters as can be seen in Figure 2.
Figure 2: Cold rolled steel panels coated with a formulation based on the water-borne binder Dynasylan® SIVO 140. Procedure: Alkaline cleaning (60 s, pH 11, 65 °C). W140-5. Wet film thickness is 90 and 250 µm. The time to get touch-dry was measured at 10, 20, 30 and 40 °C at a relative humidity of 50 %.

Figure 2 contains the time for the drying. The drying time is dependent on the wet film thickness, temperature and humidity. At a wet film of 90 µm the formulation dries after 6 minutes at 10 °C and a relative humidity of 50 %. The time to get touch-dry is reduced to 1 minute at 40 °C. If the wet film thickness is 250 µm (right hand side in figure 1) it takes more time for the zinc dust coat to get touch-dry. At 10 °C it takes 25 minutes and at 40 °C it takes 4 minutes at a relative humidity of 50 %.

The silanol groups are activated when the water evaporates but full curing takes more time. Curing time for the zinc dust paint also depends on the temperature, relative humidity and wet film thickness. The curing time was shorter when the humidity is higher. Usually the zinc dust coating based on Dynasylan® SIVO 140 can be overcoated after some hours or one day.

Figure 3 shows a comparison of different commercially available types of zinc dust paints on cold rolled steel panels. On the left hand side a solvent-borne one-pack zinc dust paint, in the middle a solvent-borne two-pack zinc dust paint and at the right hand side a water-borne two-pack zinc dust paint based on Dynasylan® SIVO 140.
Figure 3: Cold rolled steel panels coated with different types of zinc dust paints. Left hand side: one-pack solvent-borne zinc dust paint; middle: two-pack solvent-borne zinc dust paint; right hand side: two-pack water-borne zinc dust. Cleaning procedure: Alkaline cleaning (60 s, pH 11, 65 °C). Water-borne corrosion protection formulation: W140-5. The curing of all three systems was done at 20°C for 3 days (dry film thickness ~ 35 µm). The coated panels were placed in the salt spray chamber and tested according to EN 9227.

Figure 3 contains the results of the cold rolled steel plates coated with different types of zinc dust coatings after 210 hours in the salt spray chamber. The coated cold rolled steel panel at the left side shows some white rust in the area and more white rust at the scribe after 210 hours in the salt spray test. The coated cold rolled steel panel in the middle behaves similarly when compared to the one-pack zinc dust paint. There is some white rust in the area and more white rust at the scribe. The water-borne zinc dust paint based on Dynasylan® SIVO 140 shows some discoloration in the area but there is no white rust visible whether in the main area or at the scribe.

Dynasylan® SIVO 140 is a binder that is flexible and thus can be used to formulate thin and thick film corrosion protection systems. Overcoating is possible with different coating systems and typical epoxy coatings show very good adhesion. Test results of coated cold rolled steel panels after 1200 hours in the salt spray test can be seen in figure 4.
Figure 4: Cold rolled steel panels coated with an epoxy coating (left hand side) and a water-borne zinc dust paint based on Dynasylan® SIVO 140 (right hand side). The cold rolled steel panel at the right hand side was over coated with an epoxy resin. Cleaning procedure: Alkaline cleaning (60 s, pH 11, 65 °C). Water-borne corrosion protection formulation W140-5. The curing of the zinc dust paint was done for one day at 20 °C (dry film thickness ~ 35 µm). Both panels were coated with a two-pack epoxy coating and cured at 60 °C for 2 hours (60 µm dry film thickness). The coated panels were scribed and placed in the salt spray chamber for 1200 hours. The salt spray test was done according to EN 9227.

Figure 4 contains the results of two coated cold rolled steel panels after 1200 hours in the salt spray chamber. The sample at the left hand side was cleaned and coated with a two-pack epoxy coating. The dry film thickness was 60 µm. There is massive corrosion around the scribe and about 50 % of the coating is delaminated. The steel panel at the ride hand side was coated with the water-borne zinc dust paint based on Dynasylan® SIVO 140 and over coated with a two-pack epoxy coating. The water-borne zinc dust paint offers good corrosion protection. There is no white or red rust at the scribe and no delamination of the coating is visible even after 1200 hours in the salt spray chamber.
Summary

Dynasylan® SIVO 140 is a novel water-borne organic-inorganic binder designed for two-pack water-borne reduced zinc or zinc rich paints. The binder offers many formulation options with fillers and pigments. The advantages of Dynasylan® SIVO 140 include:

- improved heat resistance compared to organic binders
- almost zero VOC
- low temperature curing
- low or higher film thicknesses are possible
- Dynasylan® SIVO 140 is more environmentally friendly than traditional zinc silicate coatings based on silicic acid esters