Corrosion Protection of Metallic Surfaces

Corrosion protection and prevention is of central importance in all sectors of industry, because corrosion damage will lead to high secondary costs. For the coatings industry there is a high demand to stop or at least to slow down these processes especially for industrial plants.

Due to increased environmental awareness of the customers and also as a result of legal regulations (e.g. VOC-regulation) water-based varnishes will be used more extensively. However, it’s a challenge for the coatings industry to produce aqueous coatings with good corrosion protection.

The efficiency of antirust coatings depends on the extent of substrate preparation. The smooth metallic, dry and grease free surface is an ideal foundation for long-term protection against corrosion. These conditions are not always met in practice since in many cases residual rust remains on the surface and in the pores. At first anticorrosive effects seem to be satisfactory. However, after some time iron panels will be destroyed by corrosion bottom-up.

Rust is the result of oxidation of iron exposed to aerial oxygen. It is a rather complicated process, which can be described schematically by the following reaction mechanism:

\[
\begin{align*}
2 \text{Fe} & \rightarrow 2 \text{Fe}^{2+} + 4e^- \\
\text{O}_2 + 4e^- + 2 \text{H}_2\text{O} & \rightarrow 4 \text{OH}^- \\
2 \text{Fe}^{2+} + \text{H}_2\text{O} + \frac{1}{2} \text{O}_2 & \rightarrow 2 \text{Fe}^{3+} + 2 \text{OH}^- \\
2 \text{Fe}^{3+} + 6 \text{OH}^- & \rightarrow 2 \text{Fe} (\text{OH})_3 \\
2 \text{Fe} + 3 \text{H}_2\text{O} + 1 \frac{1}{2} \text{O}_2 & \rightarrow 2 \text{Fe} (\text{OH})_3
\end{align*}
\]

This is a classical redox reaction. By interrupting one of these reactions the process is completely interrupted and therefore corrosion is stopped.

Corresponding additives or corrosion-retarding pretreatments of the substrate has to be performed if using water-based corrosion protection systems, too. Each of these methods have their pros and cons:

- Pretreatment with primer means an additional work step
- Corrosion protection pigments need a minimum layer thickness
- Many corrosion inhibitors are not stable against pH influences and humidity

It is therefore important to use additives which can be incorporated in nearly all coating systems, can be applied on roughly derusted surfaces and will guarantee long-lasting protection from corrosion.

An effective protection against corrosion should

a) prevent the contact of corrosive active substances (mechanical barrier effect) or/and
b) interfere into the electrochemical process of corrosion so that corrosion is prevented or at least strongly delayed (electrochemical influence)
This can be realised very effectively by the formation of metallo-organic complexes, the so called chelate complexes. Chelate complexes have got large importance in nature and also in chemical analysis as extremely stable compounds (haemoglobin, vitamin B_{12}, aluminium-detection with alizarine etc.)

By forming a metal chelate further oxidation of the metal substrate is prevented by stopping any further reaction of the Fe^{3+} (s. reaction scheme).

This reaction is simplified, a transformation of instable Fe-(III)-oxides into stable Fe-(II)-oxides, as a component of very hardly soluble chelate complexes. Iron-(II)-compounds are known, e. g. from iron oxide-pigments, as very stable compounds. When applied as a primer on an iron substrate with remaining rust, very stable, metal organic layers are obtained, which cannot be oxidised any more.

It provides strong adhesion at the metal surface, so that bounded iron ions are not available for continuing electro-chemical corrosion any more. Furthermore the construction of this layer will effectively prevent any further attack of oxygen on the metal below, describable as a barrier layer. A chemical compound between metal surface and organic coating is formed. The result is long-lasting protection from corrosion.

The corrosion inhibitor SCHWEGO® corrit 6831 developed by Schwegmann Company exactly acts according to these principles. It is similar to KORRODUR which has been established in the market for years. Therefore both products offer corrosion protection for iron substrates and can be used in many coating systems (repair coating systems, DIY, one-layer rust protection systems):

- Existing residual rust is passivated by transforming it into exceptional stable metal complexes.
- The wetting of the substrate is improved.
- The adhesion of the varnish layer to the substrate is optimised.
- It can be applied on rusty surfaces – only loose rust has to be removed.

SCHWEGO® corrit 6831 is suitable for water-based coating systems with almost all current resins and is added by 2 - 5 %. Practically every coating system can be provided with corrosion-inhibiting properties without any further changes of the formulation.

KORRODUR is added to about 3 - 5 % to solvent borne systems.
As an example of a practical application the photo of a coating after several months of outside weathering exposure is shown.

On the left hand side you can see the comparison. The photo on the right hand side shows the sample with 3% SCHWEGO® corrit 6831. In the upper half water-based primers (red) were applied in each case, in the lower half white coatings were applied. An example of an guide formulation are shown on the following page.

The metallic surface of the damages remains shinningly metallic and shows no rust if using 3% SCHWEGO® corrit 6831. Apart from this some discouloration is seen which can be attributed to the reaction with the chelate forming additive and does not show any beginning rust. The compared sample containing Zn is completely rusty at the cross cut.
Description: aqueous metal primer, red oxide  
Base: Alberdingk AS 2681, acrylate acid ester

Composition:

1. Water 10.4
2. Dowanol DPM 3.8
3. SCHWEGO® foam 8013 (Schwegmann) 0.6
4. Talkum AT extra 5.0
5. Microdol Extra 8.0
6. Zinkphosphat ZP 10 10.0
7. Zinkwhite Harzsiegel 0.5
8. Bayferrox 130 M 8.5
9. SCHWEGO® pur 8350 (Schwegmann) 1.2
10. Propylen glycol 11.0
11. SCHWEGO® corrit (Schwegmann) 3.0

Mixing and then disperse up to a fineness of grind of 15-20 µm, for about 20 minutes
then prepare the following items and add the above mentioned paste slowly stirring constantly

12. Alberdingk AS 2681 30.0
14. Synthetic Resin EP-DS 50 5.0

Total formulation: 100.0

Processing

Weigh the items 1 up to 10 and dissolve them, then add item 11 and disperse them with the aid of a
dissolver up to a fineness of 25 –30µm. Prepare the items 12 to 14 and incorporate the colour paste.
Homogenize for about 5 minutes.
Adjustment of viscosity: propylene glycol

Additional hints:

SCHWEGO® corrit 6831 has been incorporated into this corrosion protection primer, because this
product converts existing rust and prevents from the rust underneath the paint. Therefore this corrosion
protection primer has an improved adhesion and protects against rust well.