Trivalent chromium passivation technology:

Low-cost, environmentally friendly conversion coating for improved corrosion protection of zinc/zinc alloy-coated steel coils

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Contents

1. General

A fresh zinc-coated or galvanized steel coil surface is prone to oxidation or corrosion when being exposed to humid environments during shipping and/or storage. This type of zinc corrosion is often called “wet storage stain”. Historically, toxic hexavalent chromium (Cr6)-based passivation solution is applied onto a fresh zinc-coated steel coil surface to form an anticorrosive thin layer (conversion coating). To date, environmentally friendly alternatives have been developed and are in use in steel coil industry. The most successful alternative technologies include:

- Silane-based, Cr-free passivation
- **Trivalent Chromium (Cr3) passivation**
- Cr-free Thin Organic Coatings (TOCs)

Figure 1 shows our Cr3 passivation product (XTC-300) ready to ship to our clients’ plants (a) and the XTC-300 passivated galvanized steel coils ready to ship to end users (b)

(a)

(b)

Figure 1. (a) Totes with the Cr3 passivation solution (XTC-300) to be shipped to client sites; (b) Cr3 passivated galvanized steel coils ready to ship to end users

2. Trivalent chromium passivation technology

2.1. Mechanism

A Cr3 passivation thin film, also called conversion coating, is formed by reacting with zinc surface. The film formation mechanism is thought to be in-line with an electrochemical dissolution-precipitation theory, Figure 2 illustrates the formation of a Cr3 passivation film on a zinc/zinc alloy coated steel surface, which consists of 2 steps:

1) Anodic dissolution of zinc surface to release zinc ions (Zn^{2+}), and
2) The reaction among Zn^{2+}, Cr^{3+} complex and phosphate ions results in an adherent and dense precipitation layer, i.e., a Cr3 passivation film (Cr3 conversion coating)

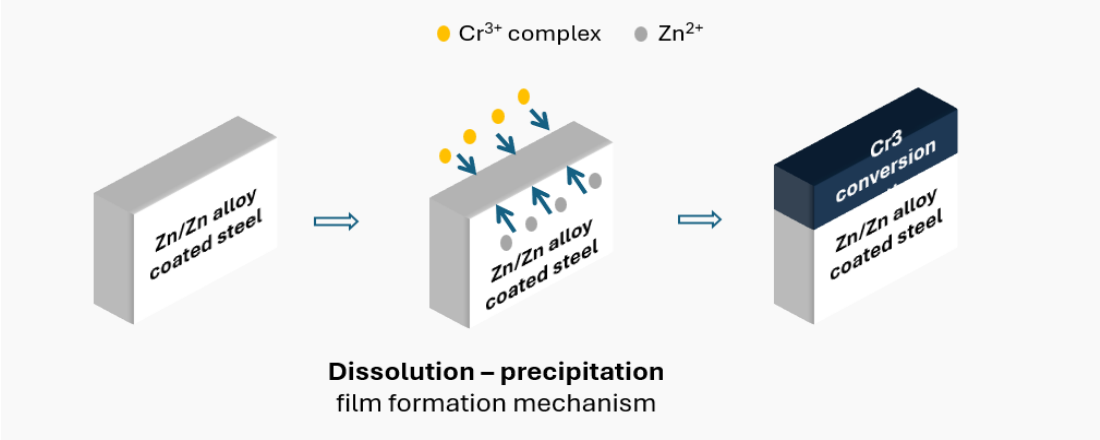


Figure 2. The formation mechanism of a Cr3 conversion coating on zinc surface

2.2. Products and lab test results

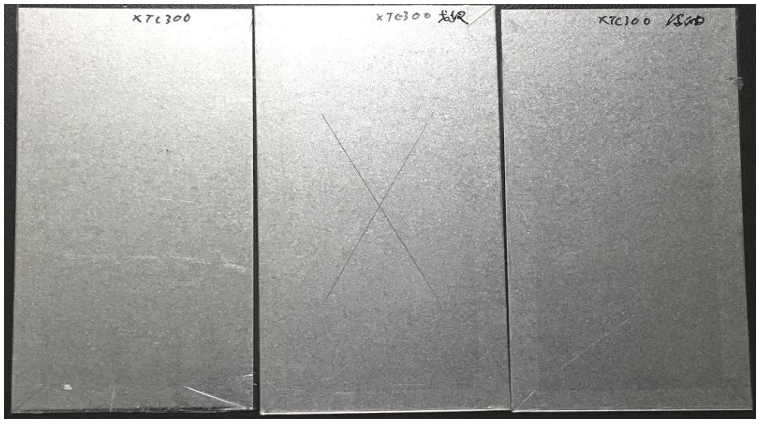
Our Cr3 products have been used on zinc and zinc alloy-coated steel coils such as GI (or HDG) and Zn-Al-Mg alloy-coated steel. The main industry served is outdoor construction industry where bare corrosion protection of galvanized steels and cost effectiveness are highlighted.

2.2.1. Cr3 passivation products for zinc-coated steel (GI)

XTC-300 is a dark green, aqueous Cr3 passivation solution (pH < 2.0, ~18% solids). It provides excellent corrosion resistance and RoHS compliant.

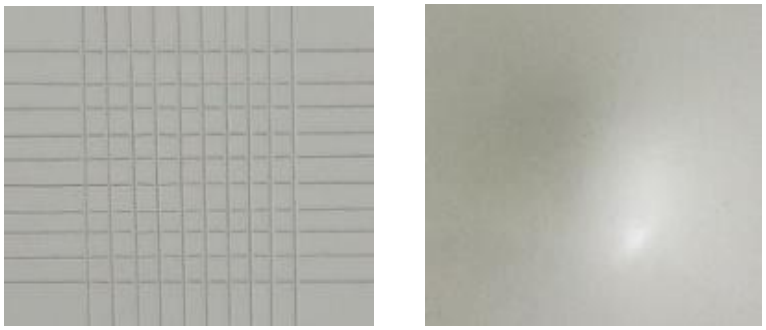
Table 1. The test results for XTC-300-passivated GI sheet

Test items		**Test result** (Coating weight: 30mg(Cr)/m^2)
Corrosion resistance (Salt spray test)	Flat area	No rust after 120 h
	"X" scribed area	No rust, no delamination after 72 h
	Oiled area	No rust after 96 h
Heat resistance (240℃*20min)		No yellowing
Humidity resistance (50°C/95%Rh/120h)		No rust
Solvent resistance (MEK and 80% ethanol, 20x double rubs)		No changes in appearance
Paint adhesion (powder coat)		Crosshatch: no delamination
		Impact: no cracking



(a) (b) (c)

Figure 3. SST results for XTC-300 passivated GI sheet; (a) flat area (no rust after 120 h), (b) "X" scribed area (no rust and no delamination after 72 h) and (c) oiled area (no rust after 96h)



(a) (b)

Figure 4. Paint adhesion results for XTC passivated GI sheet; (a) Crosshatch test (no paint loss, 5B) and (b) impact test (no cracking) (paint: Akzo Nobel polyester powder coat (60-80 μm))

XTC-300Z significantly improves the formability of passivated GI sheets. Compared to XTC-300, it not only provides excellent corrosion resistance, but also self-lubrication property that enables downstream customers to eliminate metal forming oil during stamping and/or bending GI sheets and to achieve overall cost saving.

Table 2. The test results for GI passivated with **XTC-300Z**

Test items		**Test result** (Coating weight: 40mg(Cr)/m^2)
Corrosion resistance (Salt spray test)	Flat area	No rust after 120h
	6-mm cupping dome area	No rust, no delamination after 72h
	Oiled area	No rust after 96h
	"X" scribed area	No rust after 72h
Heat resistance (240℃*20min)		No yellowing
Humidity resistance (50°C/95%Rh/120h)		No rust
Solvent resistance (MEK and 80% ethanol, 20x double rubs)		No changes in appearance
Self lubrication (friction co-efficient, μ)		0.14



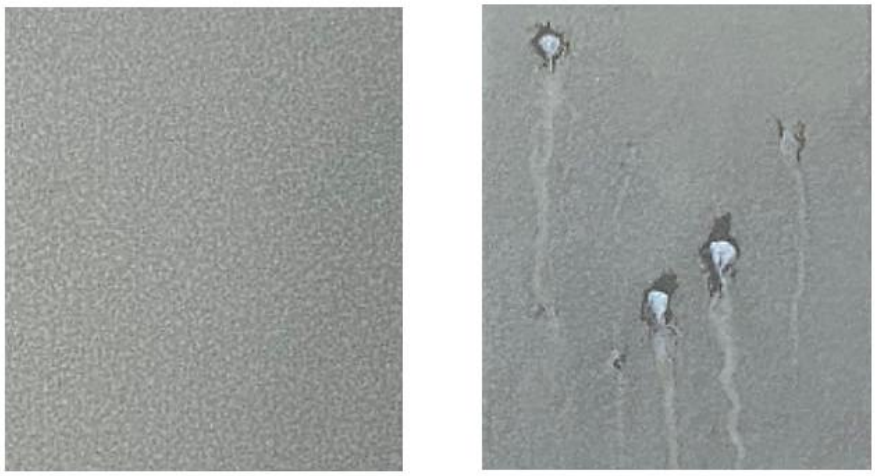
Figure 5. XTC-300Z passivated GI sheets after stamping and bending process without the use of metal forming oil. (to be used as bottom trays for plastic ton drums)

2.2.2. Cr3 passivation product for Zn-Al-Mg alloy-coated steel (Zn-Al-Mg)

XTC-400: A green, aqueous Cr3 passivation solution (pH < 2.5, ~18% solids). It offers a combination of desirable properties including excellent corrosion resistance, blackening resistance and suitable for Zn-Al-Mg alloy coatings with different compositions, such as Zn-2Al-2Mg, Zn-6Al-3Mg, Zn-11Al-3Mg.

Table 3. The test results for XTC-400 passivated Zn-6Al-3Mg sheet

Test items	**Test result** (Coating weight: 50mg(Cr)/m^2)
Corrosion resistance (Salt spray test)	No rust after 240 h
Heat resistance (240℃*20min)	No yellowing
Humidity resistance (50°C/95%Rh/120h)	No rust, no blackening
Solvent resistance (MEK and 80% ethanol, 20x double rubs)	No changes in appearance
Paint adhesion (powder coat)	Crosshatch: no delamination/5B
	Impact: no cracking



(a) (b)

Figure 6. 240-h SST results for Cr3 passivated Zn-6Al-3Mg sheet; (a) XTC-400 passivated (no rust) and (b) competitor's Cr3 passivated (corroded with white rust)