SpecialChem
The material selection platform

Autonomic Materials

CASE STUDY

New Construction Application: Extend Protection and Prevent Corrosion with Self-Healing Coatings

Additive: Microencapsulated self-healing agents

Key benefits

- Extended coating lifetime
- Reduced total cost of ownership
- Long-term corrosion protection
- Thermal stability

Applications

- Oil and Gas
- Heavy Equipment
- Mining
- Industrial

The Challenge

Corrosion is a primary cause of failure for steel constructions. A common way to protect the assets against corrosion consists of metallic powder pigments, usually zinc-based, with an electrochemical potential that is higher than that of steel. Such particles create an electrically conductive net, which acts as cathode protection: they oxidize at the place of the protected substrate and when their resource is exhausted, the substrate can be cleaned and re-painted again. However, cracks form due to the atmospheric deterioration and oxidative zinc depletion. So, how can we prolong the service life of protective coatings?

The Solution

The relatively new and highly effective way to extend the service life of protective coatings is to add self-healing additives to the coating composition. **Autonomic Materials self-healing additives** are incorporated into the coating formulation in the form of microcapsules containing a liquid healing agent. When the shell of a capsule is ruptured by damage to the coating, the liquid healing agent flows out and fills the crack, driven by capillary forces. The liquid quickly polymerizes and provides self-healing of the crack, thereby preventing further degradation and subsequent delamination. In addition, the polymerized healing agent protects the coating/metal interface at the site of damage from moisture penetration, which further minimizes the adhesion loss and formation of blistering defects.

Performance improvements are an important consideration for any asset owner. However, the total cost of ownership is just as important. As such, financial models have demonstrated that AMI's self-healing additives are cost-beneficial for a wide range of applications. Specifically, AMI's self-healing additives can lower the cost of maintaining assets in both moderate and extreme locations; from urban water towers to remote offshore oil rigs, for example by reducing the regular maintenance cost by more than 40 % over a 25-year life cycle.

› Self-healing additives improve protective performance of coatings

A self-healing additive **improves the protective performance of a coating after damage**. In the experiment described below, the protective performance of a 75 µm zinc-rich epoxy primer is compared to the same primer with 4 wt% self-healing additives incorporated. The test is conducted on cold rolled steel and the coatings are damaged using a 186 µm scribe tool to simulate relevant real world conditions. Both kinds of panels (control and self-healing) are exposed to a corrosive salt fog environment and the resulting values of electrochemical impedance are determined in a 3wt% NaCl 3-electrode electrochemical cell. See *Figure 1* below.

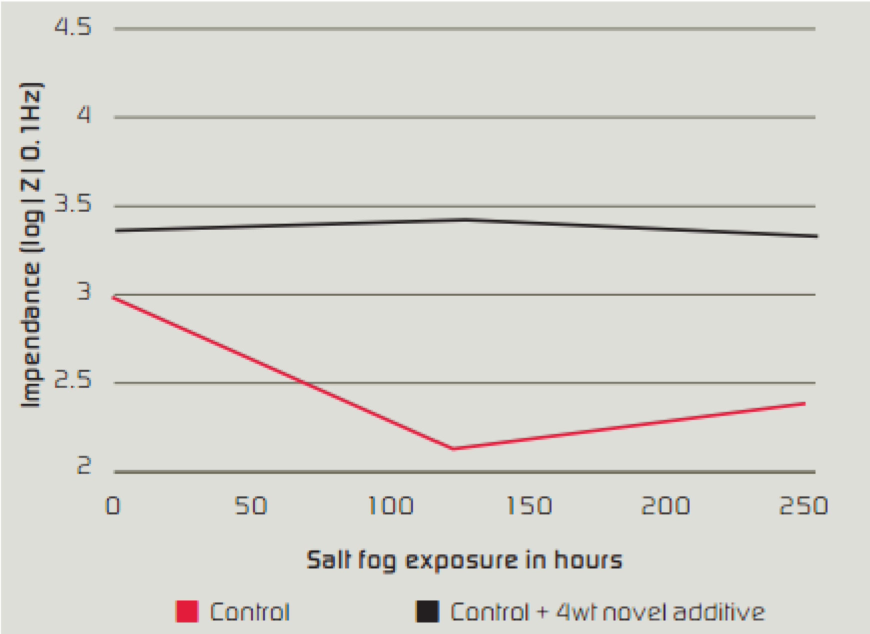

Figure. 1. Electrochemical characterization via salt fog exposure

During the first 250 hours, the standard zinc-rich primer without microcapsules experiences a decrease of impedance due to penetration of electrolyte solution into the porous surfaces at and away from the original damage.

In comparison, the primer with the self-healing additive incorporated into the formulation displays a very different trend, where the added microcapsules provide **improved protective performance** throughout the entire 250 hours of salt fog exposure.

› Self-healing additives help coatings maintain adhesion after damage

After exposure to the corrosive salt fog, there are **fewer cracks** in the self-healing coating and there is almost **no adhesion loss**. In this test, both control and self-healing formulations were applied at 50-75 µm dry film thickness on cold-rolled steel panels and damaged at two locations using 186 µm and 500 µm scribe tools. As displayed in *Figure 2*, the blistering is significantly reduced with the novel additive already after 250 hours of exposure due to reduced ingress of moisture, after which the superior performance of the self-healing coating is maintained throughout the entire 500 hours of exposure. However, the zinc-rich primer is gradually depleted and massive blistering and corrosion results in significant loss of adhesion of the control coating.

After 250 hours **After 500 hours**

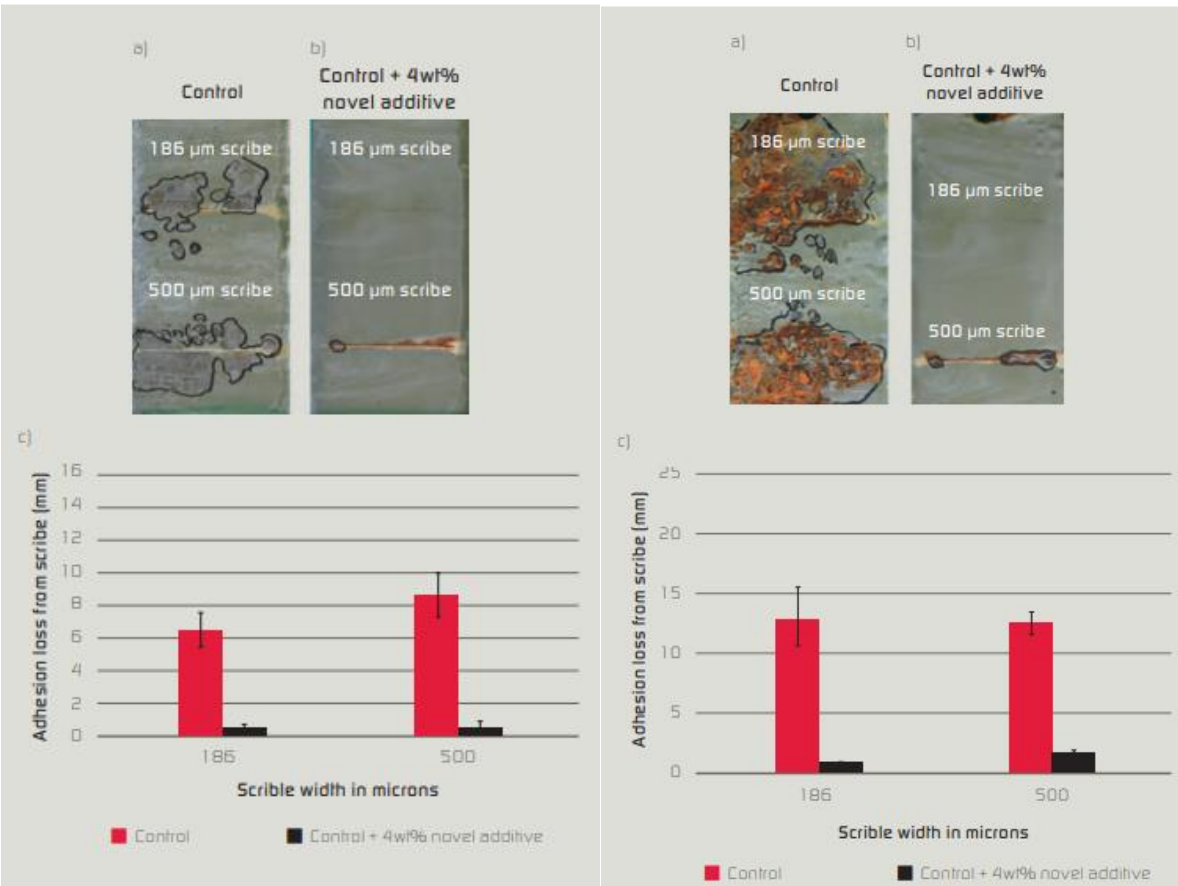

Figure. 2. Single layer two-component epoxy-polyamide zinc-rich primer coatings after 250 hours (a) and 500 hours (b) of salt fog exposure followed by evaluation of adhesion (c).

In conclusion, this novel additive provides a self-healing ability for protective coatings and is proven to be **effective in severe corrosion conditions**. Use of this self-healing additive significantly extends the service life of protective coatings, therefore providing significant maintenance cost savings by extending the period between maintenance work required. The performance improvement is achieved by a combination of reduced coating porosity and maintained coating adhesion after damage to the coating.

Autonomic Materials AMPARMOR™ products offer remarkable improvement in coating performance by:

- Preventing undercut corrosion and maintaining coating adhesion after damage
- Improving protection of metal assets, extending coating lifetimes and reducing overall maintenance costs
- Providing effective healing even at low concentrations, which allows for tailored coating performance to satisfy specific end-use application demands
- Ensuring automatic healing at ambient conditions without external/human intervention

Visit the self-healing additives platform technical center

Browse through Autonomic Materials Technical Data Sheets (TDS)