Progress in Organic Coatings 61 (2008) 126–135

PROGRESS IN ORGANIC COATINGS

www.elsevier.com/locate/porgcoat

Influence of UV weathering on corrosion resistance of prepainted steel

J. Mallégol [a,*], M. Poelman [b], M.-G. Olivier [c]

[a] ArcelorMittal Liège - R&D, boulevard de Colonster B57, 4000 Liège, Belgium
[b] Materia Nova ASBL, Rue de l'Epargne 56, 7000 Mons, Belgium
[c] Faculté Polytechnique de Mons, Rue de l'Epargne 56, 7000 Mons, Belgium

Received 1 June 2007; accepted 4 September 2007

Abstract

It has been observed that UV weathering and corrosion resistance tests are often performed separately, without taking into consideration their reciprocal influence. This is the case in the field of prepainted steel, where the European norm considers either UV durability or corrosion resistance. There is therefore no real evaluation of the global durability of the system. The aim of the present study is to show the influence of the photo-oxidation of painted layers on their barrier effect. This can lead to the formation of small blisters during field exposure. The blistering observed in natural exposure is never observed in individual accelerated corrosion tests. The depth of degradation from the surface of prepainted panels has been determined with infrared spectroscopy. Successive abrasions and FTIR analysis in ATR mode (attenuated total reflectance) allow us to determine oxidation profiles that can be well correlated with the decrease of barrier properties of painted systems measured with electrochemical impedance spectroscopy (EIS). The blistering has then been reproduced by exposing UV-weathered samples in a salt spray device.
© 2007 Elsevier B.V. All rights reserved.

Keywords: Corrosion; UV weathering; Photo-degradation; Protective coating; Barrier properties; Blistering

1. Introduction

In the field of construction, aesthetics is the most important criterion for evaluating the quality of a protective coating. The color and gloss retentions of coatings need to be very good, but with metallic products corrosion defects can also degrade considerably the appearance. The European norm EN 10169-2 considers the two types of degradation for samples exposed in separate laboratory accelerated tests, but also in natural outdoor exposure. However, for outdoor exposure, the corrosion and the UV resistance are always evaluated separately and generally on different locations (corrosive sites or UV-rich sites). With regards to this norm (and also many others in the field of coatings evaluation) it is thus noteworthy that the two tests taken separately do not allow an evaluation of the "global durability" (UV resistance + corrosion resistance).

When UV light, water and temperature changes are important factors in the field exposure, then Skerry and Simpson concluded that it should be incorporated into the accelerated corrosion test [1]. Results of their study suggested that UV weathering of paint and associated substrate corrosion were interrelated phenomena. The cyclic exposure to UV radiations/humidity and to temperature/dilute electrolyte therefore allows integrating more parameters existing in the real-life in a single test. With this consideration in mind, several researchers have tried to compare some tests mixing UV weathering and corrosion [2–6]. However, no consensus exists and combined accelerated/cyclic tests still need to be improved for better correlations with field exposure. There is, for the time being, no universal way of predicting the long-term behaviour of coatings with different chemistries in various locations around the world.

The aim of our study is not to present a substitution test for those already described in norms or in the literature. We aim at confirming that corrosion tests alone are not necessarily representative of the degradation occurring during natural exposure, when UV weathering of coatings can also be significant. Based on results obtained after 10 years of natural exposure in Hendaye (South of France), it indeed appears that one of the main defects for prepainted panels exposed at 5° or 45° South, is their blistering on flat areas. A lot of little blisters start appearing on defective systems after about 6 years exposure. These blisters can degrade the overall appearance of panels as shown in Fig. 1. In some cases blisters can even be "open" and can be considered as small flakes. It is remarkable that the accelerated laboratory

* Corresponding author. Tel.: +32 42 36 89 24; fax: +32 42 36 88 98.
E-mail address: jacky.mallegol@arcelormittal.com (J. Mallégol).

0300-9440/$ – see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.porgcoat.2007.09.026

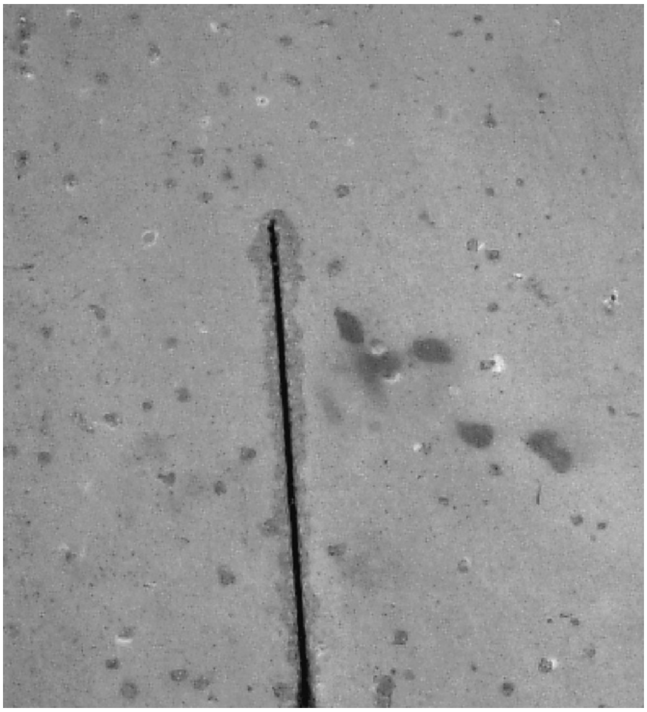

Fig. 1. Example of blistering on a red sample exposed for 10 years on natural exposure site in Hendaye (45° South exposure). The scribe is shown to evidence that corrosion on scribe is not the main visual defect.

tests for corrosion resistance do not lead to this kind of defect. It is thus interesting to wonder what the origin of such defects is.

It is known that the photo-oxidation of organic coatings occurs progressively starting from the surface [7]. The top surface is always more degraded, both because the light is not filtered, and because of oxygen diffusion from the surface. In many systems one can thus observe an oxidation profile in the depth of the coating. Because an oxidation of the polymer network leads to modifications in its chemistry and in its polarity, the solubility of water (and thus the barrier effect) could be modified, as demonstrated by several authors [8]. The role of the barrier layer on the resistance of the system to corrosion is well established, although sometimes not fully understood [9,10]. Electrochemical techniques, and especially impedance spectroscopy (EIS), have been shown to be very useful methods for the study of the performance of protective coatings [6,11–16]. Due to its sensitivity and short testing time, EIS has become more and more used over the last few years. From the analysis of the EIS diagrams with the appropriate electrical equivalent circuit, this method allows obtaining coating properties such as water permeability, coating porosity and delaminated area. These data are often used to predict the long-term behaviour of coatings or to rank various coatings with respect to their corrosion protective properties.

In the present paper, we have tried to reproduce the phenomenon of blistering on flat areas for long-term exposures, and thus to evidence the relationship between UV degradation of paint and corrosion resistance of prepainted steel. For this purpose, panels of nine different paint systems have been exposed to UV irradiation in QUVA devices, prior to salt spray exposure. The modification of the barrier effect induced by UV degradation has been measured by EIS, and correlated to oxidation profiles appearing in the paint and measured with Fourier transform infrared (FTIR) spectroscopy. The formation of blisters in salt spray exposure is then explained through the evolution of these coating degradations.

2. Experimental

2.1. Materials

Prepainted steel panels were selected from a range of commercial products. A prepainted panel is constituted of zinc-coated steel with three different layers. A surface treatment converts the surface and promotes the adhesion of the organic layers. The primer is typically about 5–10 μm thick and contains anti-corrosion pigments for corrosion protection. It must also favour the adhesion of the topcoat that is about 20 μm thick. The topcoat brings barrier effect, mechanical resistance and aesthetics to the prepainted panel. Thermoset primers and topcoats are oven-cured in order to evaporate solvents and to allow the crosslinking. The nature of primers and topcoats used here are reported in Table 1. They are based on polyurethane (PUR) or polyester (PES) resins.

Nine polyester-melamine topcoats (PES) have been chosen for this study. In order to estimate the durability of products of different performances, three different kinds of products based on their UV resistance have been selected, which can be called “standard”, ‘high durability” or “very high durability”.

In order to check the influence of the primer thickness on the barrier effect, two different thicknesses have been tested (samples numbers 2 and 3).

2.2. Testing methods and equipment

2.2.1. Accelerated UV weathering

Test no. 1. Samples have been studied following EN 10169-2 accelerated testing procedure, which consists in a 2000 h exposure in QUVA with alternated cycles (4 h irradiation/4 h condensation). This test allows obtaining a ranking of samples in terms of UV resistance.

Test no. 2. Samples have also been continuously irradiated in a QUVA device (Q-Panel) at a controlled irradiance of 0.89 W/m^2

Table 1
Characteristics of samples used in this study

Code	Primer resin	Topcoat	Color	Internal UV ranking[a]
1	PES	PES	Blue	STD
2	PES (5 μm)	PES	Brown	VHD
3	PES (15 μm)	PES	Brown	VHD
4	PES	PES	White	VHD
5	PES	PES	White	STD
6	PUR	PES	White	HD
7	PUR	PES	Green	HD
8	PUR	PES	Ivory	HD
9	PUR	PES	White	VHD

[a] STD, standard; HD, high durability; VHD, very high durability.

Download English Version:

https://daneshyari.com/en/article/694006

Download Persian Version:

https://daneshyari.com/article/694006

Daneshyari.com