Temporary protection of electrogalvanized steel by nanofilms of mercaptopropyltrimethoxysilane (MTMO)

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Abstract

The γ-mercaptopropiltrimetoxisilane (MTMO) has proven to be a good temporary corrosion protection on steel, but there are few studies on galvanized steel. In this paper the effectiveness of some specific silane films was studied. They were synthesized from MTMO hydrolyzed with ethanol or methanol, applied by different methods on electrogalvanized steel and cured at different temperatures. The corrosion behavior was evaluated by polarization curves, cyclic voltammetry and humidity chamber. From the results it was concluded that the alcohol used in the hydrolysis and the curing temperature have a marked influence on the protection level afforded by the conversion film.

Introduction

The electrogalvanized steel is used in a wide range of consumer goods. Usually, this system is coated with chromate-based conversion films. Despite they are very efficient, the high toxicity and carcinogenic nature of the Cr(VI) **[1]** creates the necessity to look for new environmental-friendly alternatives as replacement **[2]**. In this sense, pretreatments with functionalized silane solutions rise as an alternative and, although they do not offer the self-healing effect afforded by the Cr(VI) ions, they are not toxic. As well, they are harder, property that makes them more resistant to erosion, and have good thermal stability **[3]**. Silane coatings protect the substrate by a barrier effect **[4]** so its protective capacity depends not only on the film thickness and porosity but also on the silane nature. The aim of this study was to evaluate the effect of the alcohol used in the hydrolysis of the silane, the application method, curing temperature and time on the morphology and protective performance of the obtained conversion films.

Experimental

The steel samples were electrogalvanized under laboratory conditions. Then, they were coated with MTMO hydrolyzed with methanol or ethanol. The curing temperature for both cases was 20, 80 or 100°C. The curing time was 10min for 80 and 100°C and 2, 30 and 90 days for 20°C. The application methods were 1min of immersion or roller application. The polarization curves were done in aerated 0.05M NaCl solution and the cyclic voltammetry in aerated borate solution (35g/L of H_3BO_3 and 40 g/L of $Na_2B_4O_7.10H_2O$) **[5]**. The accelerated corrosion test was performed in humidity chamber (ASTM D-2247). The composition and morphology of the coatings were analyzed by SEM and EDXS.

Results and discussion

Results showed that regardless of the alcohol used in the hydrolysis, an increase of the curing temperature improved the protective capacity of the conversion films. As seen in the lower current density (Table 1) and the smaller area of the anodic peak "1" (Figure 1), the MTMO hydrolyzed with ethanol had a slightly better performance for all the curing temperatures. This may be due to the better wettability of the MTMO hydrolyzed with ethanol which generates more uniform and thicker coatings than MTMO hydrolyzed with methanol (Figure 2). The silicon content determined by EDXS was 3.93% for the coated sample with MTMO hydrolyzed with methanol and 7.52% for the sample with ethanol.

Sample	J_{corr} / A.cm^{-2}
Zn	2×10^{-5}
Methanol 80ºC (M80°C)	1×10^{-6}
Methanol 100ºC (M100°C)	1×10^{-6}
Ethanol 80ºC (E80°C)	5×10^{-7}
Ethanol 100ºC (E100°C)	4×10^{-7}

Table 1. Current density of the samples coated with MTMO hydrolyzed in methanol or ethanol and cured at 80 or 100°C.

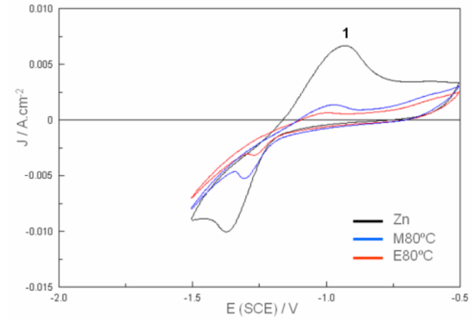

Figure 1. Cyclic voltammetry of the samples Zn, M80°C and E80°C

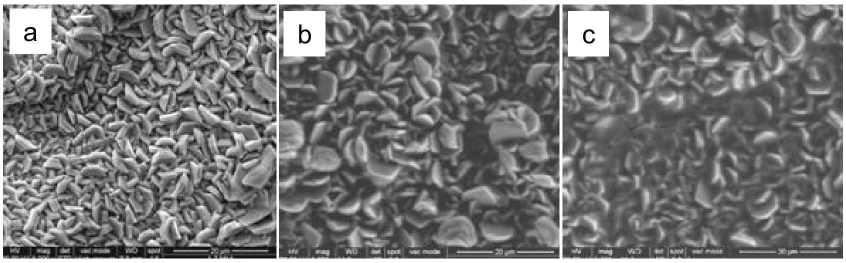

Figure 2. SEM photograph a) Zn, b) M80°C, c) E80°C

After 30 days, the samples cured at 20°C had a protective effect similar to the samples cured at 80°C. Application method did not affect significantly the performance of the system.

Conclusions

The MTMO provides adequate temporary protection to electrogalvanized steel. The increase of the curing temperature improved the protective capacity of the conversion films. Samples with low curing temperatures (20°C) exposed for 30 days in dryer had similar performance to those cured at 80°C for 10min. The hydrolysis with ethanol produced conversion films more homogeneous and thicker; as a result, it improved the system corrosion behavior.

References

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