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Electrochemical study of silane films and chromate conversion coatings applied on zinc coatings

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Abstract – Due to the Cr (VI) toxicity, non-toxic alternatives based on silane films, have been studied. The objective of this work was to study the electrochemical behavior of electrodeposited zinc coatings post-treated with silane-cerium film or Cr(VI) conversion coating. The silane film presented a leveling effect on the zinc coating surface. The EIS tests allowed the observation of a distinct kinetics of corrosion in the systems studied, indicating the presence of different corrosion phenomena after treatment with the silane film.

Conversion coating is largely used in corrosion protection; however one of the most popular and effective conversion process is based on chromate ions. Due to the Cr (VI) toxicity, non-toxic alternatives have been studied [1]. The use of silanes coatings obtained by sol-gel process is one promising alternative to corrosion resistant coatings [2, 3].The objective of this work was to study the electrochemical behavior of electrodeposited zinc coatings post-treated with silane-cerium film or Cr(VI) conversion coating. Silane-cerium coatings were obtained by dip-coating from a sol constituted by MAP and TEOS silanes precursors with the addition of cerium, while hexavalent chromate coatings were obtained by conversion treatment.

Morphology modifications were evaluated by scanning electron microscopy. The results showed that the silane film presented a leveling effect on the zinc coating surface, however, it was observed the presence of discontinuities (pores) on the silane film. Electrochemical impedance spectroscopy (EIS) measurements, allied to potentiostatic polarization curves, demonstrated that the post-treatment of zinc with hexavalent chromate conversion or application of silane promoted the increase of polarization resistance (Rp) and the reduction of corrosion current density, with superior performance to silane-cerium coating (Table 1).

The results obtained by EIS technique (Figure 1) show that the sample of not treated zinc has two capacitive loops up to 48 hours of immersion in 5% NaCl solution. These loops were associated to different phenomena: at low frequency, to the formation of a corrosion product on the zinc, and at middle frequency, to the charge transfer phenomena on zinc. After 72 hours of immersion, a third capacitive loop at high frequency can be verified; in this case, it was associated to the pore resistance of corrosion products of zinc. After treatment with silane film, three time constants became evident during all 168 hours of immersion. The capacitive loop at high frequency was associated with a pore resistance of the silane film, while the capacitive loop at middle and low frequencies were associated to silane films and a corrosion product formed by the inhibitory action of cerium, respectively. For the sample of zinc with hexavalent chromate conversion, results showed that, during the time of immersion, the coating presented a capacitive loop in the region of high frequency related to the charge transfer of zinc, and a component associated with the diffusion through the layer of conversion in low frequency.

Table 1: Electrochemical parameters obtained by potentiostatic polarization curves.

	Zn	Zn/Cr^{+6}	Zn/silane-cerium
i_{corr} (A/cm²)	1.3E-5	6.2E-7	2.6E-7
E_{corr} (mV)	-1069	-1198	-1032
Rp ($Ohm.cm^2$)	5.4E+2	4.0E+3	1.6E+4

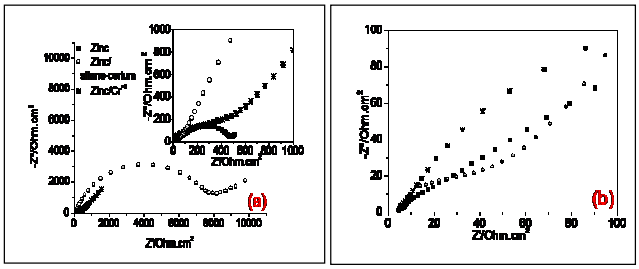

Figure 1: Nyquist diagram at low and medium frequencies; **(a)** and high frequencies **(b)** EIS measurements obtained for samples immersed for 168 hours in 5% NaCl solution.

References

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