Effects of Aging Temperature and Time on the Corrosion Protection Provided by Trivalent Chromium Process Coatings on AA2024-T3

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Abstract

Chromate conversion coatings (CCCs) provide excellent corrosion protection to aluminum alloys and possess the self-healing feature that can provide active corrosion protection.[1] However, Cr(VI) is highly toxic and efforts have been focused on development of non-Cr(VI) pretreatment coatings that still provide comparable corrosion protection to aluminum alloys.

The trivalent chromium process (TCP) coating, originally developed at NAVAIR, is one of the leading replacements on the market. The TCP coating has a biphasic structure including a $ZrO_2 \cdot nH_2O$ top layer and a K_xAlF_{3+x} interfacial layer.[2] TCP forms a partially blocking barrier layer on the alloy surface that consists of hydrated channels and or defects. It is through these channels and defects that ions and dissolved O_2 can be transported to local regions of the underlying alloy. Preliminary work in our group revealed that aging can increase the polarization resistance of the TCP coating by 3 orders of magnitude.[1] Studies have also shown that long-term (48 h) atmospheric aging produces small cracks in the TCP coating that likely adversely affect the corrosion protection.[3]

In this presentation, we will discuss the effects of aging temperature and time on the physical structure of and corrosion protection provided by TCP coatings on AA2024-T3. Corrosion initiates at the defect sites in the coating, which can ultimately lead to catastrophic failure due to undercutting of the coating. We tested the hypothesis that collapsing the channels and or reducing the number of defects in the coating might be possible through post-deposition heat treatment, and that this would enhance the corrosion protection provided by the coating. This was tested by aging the TCP-coated AA2024 alloys in air overnight at room temperature (RT), 55, 100 or 150 ºC. The TCP coating became dehydrated and thinner at the high temperatures (55 and 100 ºC). This improved the corrosion protection as evidenced by a 2× increase in the polarization resistance, R_p. Aging at 150 ºC caused excessive coating dehydration and shrinkage. This lead to severe cracking and or detachment of the coating from the surface. As the aging temperature increased, the coating became progressively hydrophobic

The TCP-coated AA2024 samples were also aged in air at RT from 1-7 days. The corrosion protection progressively improved with the aging time as evidenced by a 5x increase in R_p. As was the case at elevated temperature, the coating became more hydrophobic as the aging time increased.

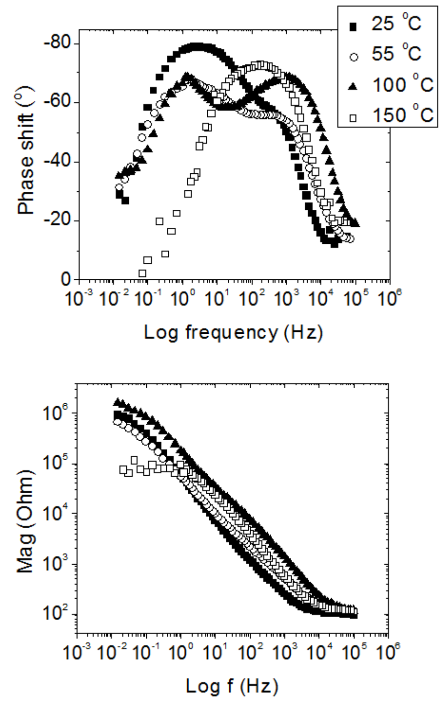

Figure 1. Bode plots for the TCP-coated AA2024 at E_{corr} after overnight aging at varied temperature: room temperature (RT, ■), 55 (○), 100 (▲), and 150 °C (□). Three measurements were made in air-saturated 0.5M Na_2SO_4.

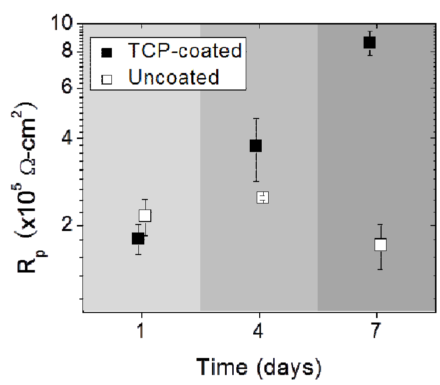

Figure 2. Effects of aging time at room temperature on R_p of the TCP-coated (■) AA2024. Data for the uncoated control (□) is also shown. Each datum is an average of 3 measurements.

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