Corrosion Protection by Trivalent Chromium Process (TCP) Coatings on Aluminum Alloys during Atmospheric Testing

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Abstract

Chromate conversion coatings (CCCs) provide effective localized corrosion protection to high strength aluminum alloys. As such, they have been widely employed in the aerospace industry.[1] However, the Cr(VI) they contain is a hazardous environmental pollutant. Therefore, significant effort has been focused on development of non-chrome alternatives that provide corrosion protection equivalent to CCCs. The Trivalent Chrome Process (TCP) coating is one of the leading replacements for CCCs.[2]

Our previous study has revealed that the TCP coating has a biphasic structure with a hydrated $ZrO_2 \cdot 2H_2O$ overlayer and an aluminofluoride interfacial layer on the three aluminum alloys (AA2024, 6061 and 7075).[3,4] The coating exhibited good stability during full immersion testing in air-saturated 0.5 M Na_2SO_4 or NaCl.[3,4,5,6] However, little is known about the stability and properties TCP coatings during atmospheric testing. Thus, the goal of this work was to assess the coating properties and corrosion resistance of the TCP-coated aluminum alloys exposed to humidified air or sulphur dioxide (SO_2) at room temperature and 55 °C.

The good structural and chemical stability of the TCP coating on three alloys (AA2024, 6061 and 7075) was evidenced by an unchanging pit density on the TCP-coated samples during a 14-day exposure to humid air at both room temperature and 55 °C. Several electrochemical properties also reflect the stability of the TCP coating. For example, the polarization resistance (R_p) of the TCP-coated samples increased during a 14-day humidified air exposure at room temperature. This may be due to the formation of an aluminum oxide layer in the defects and imperfections of the coating. The R_p values increased to a greater extent after a 14-day exposure at 55 °C (Fig. 1). Partial dehydration and shrinkage of the coating may contribute to this increase. Decreased coating porosity and increased water contact angles (Fig. 2) were observed after the 14-day exposure. Impedance measurements also showed that the TCP coating became more capacitive during exposure to humid atmosphere. Results for atmospheric corrosion testing in SO_2 at 25 and 55 °C will also be reported on as testing is currently in progress.

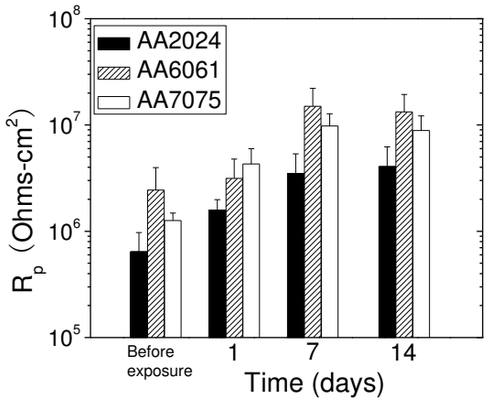

Figure 1. Polarization resistance (R_p) of TCP-coated AA2024, 6061 and 7075 in air-saturated 0.5 M Na_2SO_4 after humidified air exposure at 55 °C. The graph presents average and standard deviation values for n = 3.

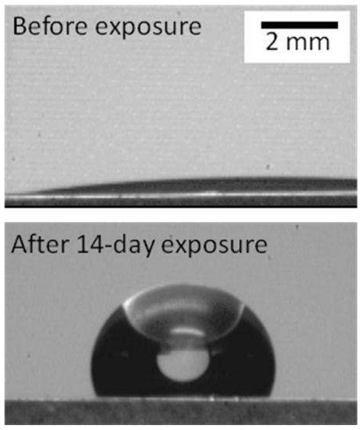

Figure 2. Optical micrographs of water droplets on the TCP-coated AA2024 before exposure and after 14-day exposure to humid atmosphere at 55 °C.

Acknowledgements

Support for this work was provided by the Office of Naval Research through grant #N00014-12-1-0227. We acknowledge the contribution of our collaborators: Gerald Frankel (OSU), Rudy Buchheit (OSU) and Mark Jaworowski (United Technologies).

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