

The Formation, Structure and Electrochemical Properties of Non-Chrome Pretreatment Coatings on AA2024

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Abstract

Chromate conversion coatings (CCCs) provide effective localized corrosion protection to high strength aluminum alloys. As a consequence, they are widely employed in the aerospace industry.¹ However, they contain the hazardous and toxic Cr(VI). There is interest in the scientific community to develop non-chrome alternative coatings that provide corrosion protection equivalent to that CCCs. The NCP (NAVAIR) and Alodine 5200 coatings are two of the chromate-free coatings currently on the market. They are considered environmentally friendly and thus exhibit lower toxicity than the chromate versions. They are designed for different purposes. For example, the NCP coating is considered as a corrosion protection coating, while Alodine 5200 is approved for use to improve the adhesion of paint. The coating may also provide some corrosion resistance to aluminum alloys.² Overall though, little is known about the chemical and electrochemical properties of these coatings on aluminum alloys during full immersion testing. This paper will discuss the formation, structure, and basic electrochemical properties of these two coating systems on AA2024.

The NCP coating is a zirconium-based system. Elemental depth profiling has revealed it contains mainly zirconium and oxygen, with some other elements, e.g. zinc, aluminum and fluoride, detected.

The 5200 coating is a titanium-based system.³ The coating on AA2024 exhibits a relatively smooth surface, except in those locations where intermetallic compounds exist (~20 μm diam., see Fig. 1). EDX elemental line profiling revealed the coating consists of titanium, zirconium and oxygen. These characteristic elements of the coating show relatively stronger signals at the Cu-rich intermetallic sites than the nearby terrace sites. The coating exhibited good structural and chemical stability during full immersion in air-saturated 0.5 M Na_2SO_4 , as evidenced by the relatively constant polarization resistance (R_p) (Fig. 2). However, in an aggressive NaCl-containing electrolyte solutions (0.5 M Na_2SO_4 +0.001 wt.% NaCl), the 5200-coated samples exhibited R_p values that decreased by 2 \times after the 14-day immersion test. Furthermore, as the concentration of NaCl increases to 0.1 wt.%, the 5200 coating exhibited even less stability as evidenced by the decreased R_p values. Unlike the TCP coatings, the Alodine 5200 coating appears unstable in chloride-containing electrolytes under full immersion.

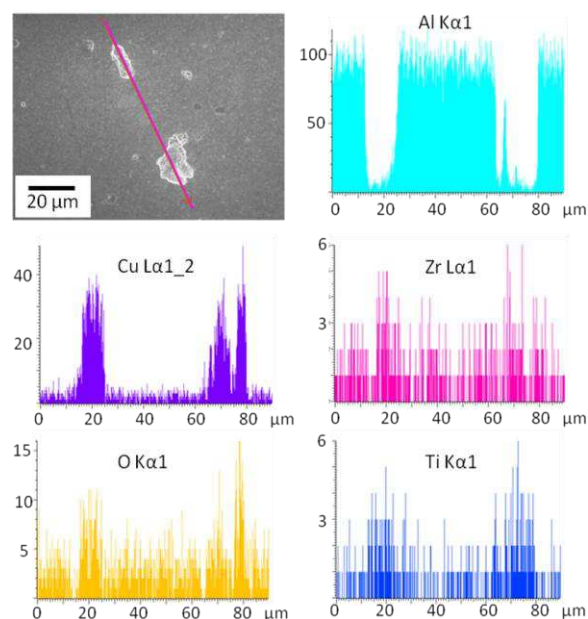


Figure 1. SEM image and EDX elemental line profiling across two intermetallic compounds on the 5200-coated AA2024 after overnight aging in air.

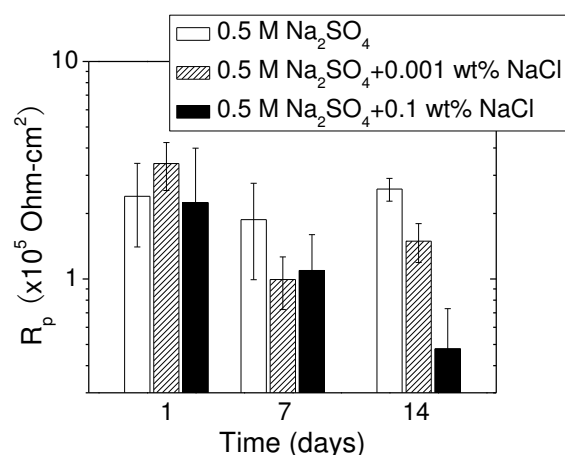


Figure 2. Polarization resistance (R_p) for 5200-coated AA2024 during a 14-day full immersion testing in air-saturated 0.5 M Na_2SO_4 with varied concentrations of NaCl, ca. 0, 0.001, and 0.1 wt.% at room temperature.

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