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Development of Chromium-Free Corrosion Resistant Conversion Coatings

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Abstract

Chromate conversion coatings applied to zinc-plated steel for corrosion protection usually consists of various chromium compounds that include hexavalent chromium (Cr^{6+}). As the use of highly toxic and carcinogenic chromium compounds has been regulated worldwide, the development of a chromium-free corrosion resistant conversion coating for zinc plating has become necessary. In this study, we used vanadium as an alternative to chromium, and successfully prepared vanadate conversion coatings and have found that it has corrosion resistance; however, the corrosion resistance of the vanadate conversion coating was lower than that of the chromate coating. Therefore, we studied improvement of corrosion resistance of the vanadate conversion coating by clarification of the vanadate conversion coating film composition and optimization of the solution composition. X-ray photoelectron spectroscopy analysis of the coating surface showed that the vanadate conversion coating mainly consists of V_2O_3. Furthermore, it was found that the $NaNO_3$ concentration in the conversion solution significantly affected the coating formation and the corrosion resistance. The concentration of $NaNO_3$ was optimized to develop an optimum vanadate conversion solution and film composition.

Keywords: Chromium-free, Zinc plating, Conversion coating, Corrosion resistance

1. Introduction

Chromate conversion coating (Cr^{6+}) is a type of surface treatment applied to zinc-plating to prevent the corrosion of steel [1]. Various interference colors normally are obtained on chromate conversion coating. And it is extreme thin film which is composed by mainly chromium compound. In general, the thickness of the chromate conversion coating is only 100-200 nm and that of the zinc electroplated layer is approximately 5-10 μm. Furthermore, the ionization energy of zinc is greater than that of iron; therefore, zinc forms the corrosion product easily. Consequently, the steel surface is protected from corrosion by the formation of corrosion products of zinc. This implies that zinc plating performs as a sacrificial layer preventing the corrosion of steel. However, surface of zinc plating easily discolor. Therefore, a chromate conversion coating is applied to protect the surface of the zinc plating. The chromate conversion treatment provides excellent corrosion resistance and is economical. However, the chromate conversion coating consists of hexavalent chromium (Cr^{6+}), the use of which has been regulated worldwide. Therefore, trivalent chromium (Cr^{3+}) conversion coatings, which are less toxic, have been developed and used for practical applications [2]. However, trivalent chromium may be converted to hexavalent chromium by some coexisting material. In addition, the cost of the trivalent chromium conversion solution is much higher than that of the chromate conversion solution. Therefore, the development of a chromium-free conversion coating for zinc plating is required for industrial applications.

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