Influence of vanadate additive on the properties of cerium conversion coatings on AZ91 magnesium alloys

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Chemical conversion coating process is an effective corrosion protection method for magnesium alloys. Recently, rare earth metal salt conversion coatings have been developed as a potential method to replace chromate conversion coatings. However, it is necessary to solve the problems like slow reaction rate and poor coating adhesion. For rare earth conversion systems, H_2O_2 is found to increase the reaction rate but the accompanying hydrogen evolution causes the formation of blisters, which deteriorate the coating adhesion.[1] Our previous works showed that adding H_2O_2 resulted in a two-layer conversion coating. The two-layer coating composed of an inner porous layer with Mg/Al oxide and hydroxide and an outer compact layer of Ce oxide (CeO_2).[2,3] Blisters are related to the breakdown of the CeO_2 layer due to hydrogen evolution.

In this study, cerium conversion coatings were made on AZ91 magnesium plates in cerium nitrate aqueous solution with H_2O_2. The evolution of the conversion coating with continued immersion was followed by varying the immersion time. H_2O_2 addition increases the reaction rate; however, the blisters on the conversion coating cause poor adhesion and deteriorate the corrosion resistance of the cerium conversion coating. An alternative approach by the addition of sodium metavanadate ($NaVO_3$) was used to solve the formation of blisters. Microstructure observation shows that complex precipitates are formed on the coating and the amount of blister is significantly reduced, as shown in Figure 1. The results suggest that the presence of VO_3^- plays an important role in inhibiting the formation of blisters.

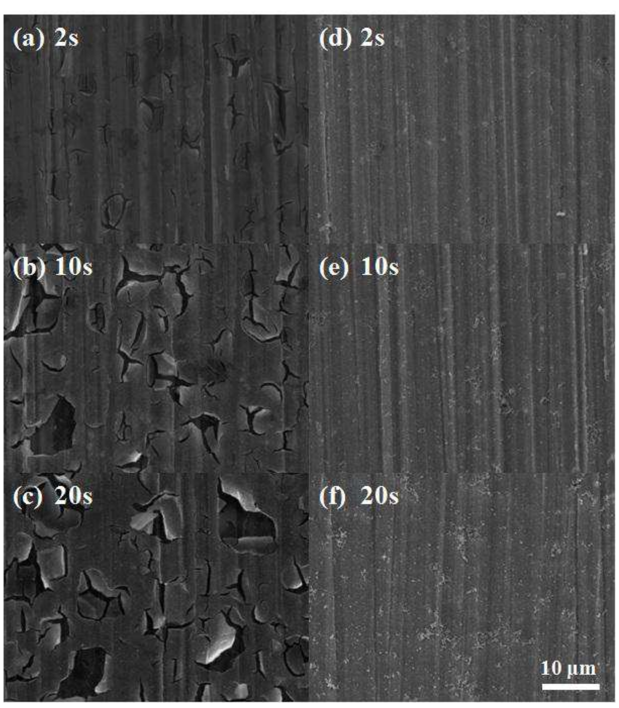

Figure 1. Surface morphology of the cerium conversion coating with/without $NaVO_3$; (a)-(c) many blisters remains on the Ce conversion coating without $NaVO_3$ and (d)-(f) some precipitates forms on the coating whereas the blisters are eliminated effectively.

The adhesion was evaluated by the tape test, and the results are shown in Table 1. By the ASTM D3359-02 standard, the coating without $NaVO_3$ is classified for 4B and the coating with $NaVO_3$ is 5B. Figure 2 shows the polarization curves in 0.05M NaCl+0.1M Na_2SO_4 solution. The corrosion current density of the untreated AZ91 is 1.71E-05 Acm^{-2}. After conversion, the corrosion current density of the cerium-coated AZ91 decreases. The corrosion resistance is improved. Notably, adding $NaVO_3$ into the conversion solution enhances the corrosion resistance. The corrosion current density decreases to 1.52E-06 Acm^{-2} when the conversion time is 20 s. Therefore, the addition of $NaVO_3$ inhibits blistering and improves the corrosion resistance of the cerium-coated AZ91.

Table 1. Results of adhesion test.

	2s	10s	20s
without $NaVO_3$	4B	4B	4B
with $NaVO_3$	5B	5B	5B

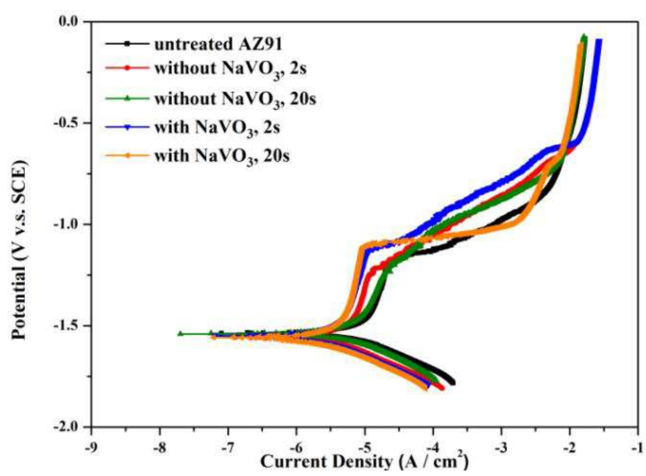

Figure 2. Polarization curves of the cerium-coated AZ91 without/with $NaVO_3$ in the conversion solution.

Table 2. Corrosion potential and current density of the various AZ91 specimens.

	E_{corr}	I_{corr}
untreated AZ91	-1.538	1.71E-05
without $NaVO_3$, 2 s	-1.555	2.91E-06
without $NaVO_3$, 20 s	-1.541	4.04E-06
with $NaVO_3$, 2 s	-1.551	1.93E-06
with $NaVO_3$, 20 s	-1.558	1.52E-06

1. M.Dabala, K. Brunelli, E. Napolitani and M. Magrini, Surf. Coat. Technol., **172**, 227 (2003).
2. C. S. Lin and W. J. Li, Mater. Trans., **47**, 1020 (2006).
3. H. Y. Su, W. J. Li, and C. S. Lin, J. Electrochem. Soc., **159**, C219 (2012)