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ORIGINAL RESEARCH ARTICLE

Formation and Corrosion Protection of Layered Double Hydroxide Film on Mg-4Li-3Al and Mg-14Li-3Al Alloys

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$Mg(OH)_2$/Mg-Al layered double hydroxide (LDH) films were prepared on the surface of single phase Mg-4Li-3Al (α-Mg phase) and Mg-14Li-3Al (β-Li phase) alloys by in situ hydrothermal in pure water with chemical-free reagents, respectively. The influence of α-Mg and β-Li phases on the formation of LDH and the corresponding corrosion resistance were investigated. The differences in the growth of LDH on α-Mg and β-Li phases were discussed. Results show that Al element exists mainly as solid solution atoms in the α-Mg phase and mainly as intermetallic compounds in the β-Li phase, which promotes the generation of LDH. Compared with the process on the surface of α-Mg phase, the pH value of the reaction solution in β-Li phase can reach the optimal value in a shorter time for LDH growth, which can effectively reduce the hydrothermal time, and the film contains a higher content of LDH. Compared with the substrate, the corrosion current density of the films is reduced by 1-2 orders of magnitude. After hydrothermal treatment for 12 h, the LDH film on LA143 alloy has the lowest corrosion current density (2.426×10^{-7} A cm^2) and dense surface.

Keywords β-Li phase, in situ hydrothermal, LDH, Mg-Li-Al alloys

1. Introduction

Magnesium and its alloys are widely applicable due to its low density, high specific strength, excellent electromagnetic shielding and other properties (Ref 1-3). The density of Mg alloys can be further reduced with the addition of Li (Ref 4, 5). The crystal structure of the alloy changes from hexagonal close packed (HCP, α-Mg) to body-centered cubic structure (BCC, β-Li) when Li content exceeds 5.7 wt.%, and α-Mg completely transforms into β-Li when Li content exceeds 10.3 wt.% (Ref 6). The plasticity of the alloy is further improved due to the addition of Li. However, the addition of Li further reduces the anti-corrosion performance of the alloy (Ref 7). Therefore, it is essential to enhance the anti-corrosion performance of Mg-Li alloys.

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LDH, as one of the chemical conversion films, has been receiving extensive attention attributed to its unique structure and properties (Ref 8, 9). Numerous researchers have prepared LDH film to improve the anti-corrosion of the Mg alloy by co-deposition, in situ hydrothermal, ion exchange and electrodeposition method (Ref 10-13). In situ hydrothermal method is widely used due to its good adhesion and simple operation. Takahiro Ishizaki et al. generated Mg-Al LDH film by using pure water without any chemical reagent based on the in situ hydrothermal, which effectively improved the corrosion resistance of the alloy (Ref 14). This provides a simple, environment-friendly and low-cost method. Zeng generated Mg-Al LDH film on the AZ31 alloy by the steam method as well as discovered the post-treatment can further improve the protective ability of the film (Ref 15). Wang prepared Mg-Al LDH film on AZ80 alloy using the steam method, of which shown that the pretreatment with citric acid (CA) increased volume fraction of the second phase and resulted in the thicker and denser film (Ref 16).

In general, alloying causes changes in the phase composition and microstructure of the alloy, that in turn has the considerable effect on the growth mode of the LDH (Ref 17). Mg-Al LDH on Mg-xCa (x = 0.5, 0.8, 2) alloys was prepared using in situ hydrothermal, it revealed that the increase in the second phase Mg_2Ca and the reduced of the grain size with the increase of Ca content promoted the growth of LDH (Ref 18). Moreover, a higher amount of Mg_2Ca phase leads to the forming thicker and more fluffy LDH film. Y in Mg-Y alloy could replace the position of part of Al in LDH, improving the stability of LDHs films. The incorporation of Y led to the forming of Y_2O_3 in the film, thus generated many bulged petals-like clusters on the MgAlY-LDH and improved its anti-corrosion properties (Ref 11, 19). The incorporation of Mn in Mg-2Zn alloy generated numerous recrystallized nucleation sites and refined grains, resulting in forming LDH film becoming thinner and denser (Ref 20). In preparation of LDH

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