
Corrosion resistance of oxide films formed on Mg Alloy by plasmaelectrolytic oxidation

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Magnesium alloys are very promising structural materials due to their low density, high ratio of strength to weight and excellent electromagnetic shielding characteristics for weight reduction in all forms of transportation. However, the high strength-to-weight ratio along with other unique properties of magnesium alloys are, unfortunately, restricted by their high surface reactivity. Thus, it is essential for Mg alloys to perform surface treatment to suppress the surface reactivity. Numerous studies have been conducted to protect pure Mg or Mg alloys from corrosion by organic coatings and chemical-conversion films. Among various types of surface treatments, protective coating fabricated by plasmaelectrolytic oxidation (PEO) is an attractive surface engineering process for corrosion control technique. PEO is performed by creating micro-arc discharge in an electrolyte and fabricates a dense oxide layer on the surface of Mg alloy. The process applies a controlled high-voltage to Mg alloy submerged in an electrolytic bath. In this study, we aimed to prepare corrosion resistant films on Mg alloy using PEO technique and evaluate the characteristics of the films.

Ca-added flame-resistant Mg alloys, AZCa612, with a dimension of 10 mm x 10 mm x 3 mm or 20 mm x 20 mm x 3 mm was used as substrates. Prior to PEO process, the substrates were degreased by ultrasonic cleaning in a mixed aqueous solution containing 40 g/L NaOH and 10 g/L Na₃PO₄·12H₂O, followed by acid cleaning in the 170 g/L HF aqueous solution. PEO was performed in a two-electrode cell. Two AZCa612 substrates were used as the anode and cathode electrodes. The electrolyte for PEO process was composed of potassium hydroxide, potassium fluoride, trisodium phosphate, aluminum hydroxide and potassium permanganate (165 g/L KOH + 35 g/L KF + 35 g/L Na₃PO₄·12H₂O + 35 g/L Al(OH)₃ + 20 g/L KMnO₄). The PEO process was provided by a stepwise increase of applying voltage. The breakdown voltage of micro-arc discharge was approximately 20 V, where the current sharply increased to 4 A and then stabilized at 2 A at 6 min after the PEO process initiated. The composite oxide film was formed on the surface of AZCa612 at a constant current of ranged between 2.0 and 2.5 A and being terminated when the voltage reached approximately 45 V at the PEO process time of 125 min.

A composite oxide film was prepared on a flame-resistant magnesium alloy AZCa612 by PEO. The thickness of the film was approximately 30 μm, where the film was composed of mainly of MgO and Mg-Mn-Al oxide. Potentiodynamic polarization curve measurements demonstrated that the corrosion current density of the composite oxide film coated AZCa612 decreased by 6 orders of magnitude compared to bare substrate. Immersion tests in 5 wt. % NaCl solution after 42 day indicated the coating phase did not change significantly, which proved that the PEO coating have superior corrosion resistance in 5 wt.% NaCl aqueous solution.

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