Enhancement of Anti-Corrosion Performance of Epoxy Coatings on Magnesium Alloys Using 8-HQ/ZIF-8@PDA Smart Nanocontainers

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Abstract: This study presents the construction of a smart nanocontainer system, in which 8-hydroxyquinoline (8-HQ) is encapsulated within zeolitic imidazolate framework-8 (ZIF-8), followed by surface polymerization with polydopamine (PDA). This nanocontainer was subsequently integrated into an epoxy resin to develop a novel anti-corrosion and self-healing epoxy coating for magnesium alloys. Experimental results demonstrate that ZIF-8, with its highly ordered microporous structure, effectively adsorbs and embeds the corrosion inhibitor 8-HQ. In NaCl solution containing extracts from 8-HQ@ZIF-8/PDA particles, the low-frequency impedance of the sample was 3.5 times higher than that in blank saline, and the charge transfer resistance (Rct) reached 5598 Ω/cm², significantly exceeding the Rct value of 168 Ω/cm² for the blank saline sample. This substantial improvement highlights the corrosion inhibition properties of 8-HQ/ZIF-8@PDA particles, thereby providing excellent anti-corrosion and self-healing performance for magnesium alloys. Additionally, PDA, rich in hydrophilic hydroxyl and amino functional groups, serves as a superior adhesive material, capable of repairing micro-pores and cracks in the coating, enhancing the interfacial compatibility between the nanocontainer and the epoxy coating. Electrochemical impedance spectroscopy (EIS) analysis indicated that the low-frequency impedance ($|Z|_{10\ mHz}$) of the 8-HQ/ZIF-8@PDA epoxy coating remained greater than 2×10^7 Ω·cm² even after 50 days of immersion. Furthermore, after 45 days of salt spray testing, the surface of the epoxy composite coating containing 8-HQ/ZIF-8@PDA remained intact without any corrosion spots, underscoring the coating's exceptional barrier properties and long-term corrosion resistance. This study provides a promising solution for the anti-corrosion protection of magnesium alloys.

Keywords: Magnesium alloys; Anti-corrosion; Self-healing; Epoxy coating; Nanocontainers