

In-Vitro Corrosion Performance of Nanocarbon-Reinforced Biodegradable Magnesium-Matrix Composites under Simulated Physiological Conditions

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Abstract: Iron, zinc, and magnesium-based alloys have attracted increasing attention in recent years as biodegradable implant materials. Among them, magnesium and its alloys have emerged as particularly promising candidates due to their excellent biocompatibility, mechanical properties comparable to natural bone, and their ability to gradually degrade in physiological environments¹. However, their excessively high corrosion rate and associated hydrogen gas evolution under in-vitro and in-vivo conditions remain major challenges limiting their clinical application². Recently, carbon-based nanostructures such as graphene nanosheets (GNS) and carbon nanotubes (CNTs) have gained significant interest in biomedical materials owing to their outstanding mechanical properties, chemical stability, and potential to improve corrosion resistance and surface bioactivity when incorporated into metallic matrices³. Nevertheless, the *in-vitro* corrosion behavior of such nanocarbon-reinforced magnesium composites under simulated physiological environments is still not sufficiently understood. In this study, AZ61 magnesium alloy matrix composites reinforced with 0.1, 0.2, and 0.5 wt.% CNT and GNS were fabricated using the powder metallurgy technique. The in-vitro corrosion performance of the composites was evaluated in simulated body fluid at body temperature (37 °C) using potentiodynamic polarization and electrochemical impedance spectroscopy (EIS). Surface morphology and phase evolution before and after corrosion were characterized by scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM-EDS) and X-ray diffraction (XRD). The results demonstrated that optimized nanocarbon reinforcement significantly enhanced corrosion resistance and promoted the formation of more uniform and protective degradation layers under physiological conditions. The composites reinforced with 0.1 wt.% CNT and 0.5 wt.% GNS exhibited the lowest corrosion current densities of 68.94 and 157.70 $\mu\text{A}/\text{cm}^2$, respectively. Compared to the unreinforced AZ61 alloy, the corrosion resistance increased by approximately eight times. Post-corrosion analyses confirmed improved microstructural stability and controlled degradation behavior, indicating enhanced surface integrity suitable for biodegradable implant applications.

Keywords: Biodegradable magnesium; CNT; Graphene; *In-vitro* corrosion

References

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