Abstract of Doctoral Thesis

Bioactive Oxide Coatings Enriched in Ca, P, Si Formed On Magnesium Via High-Voltage Anodization

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In this thesis, the results of research on the development of multifunctional plasma electrolytic oxidation (PEO) coatings on magnesium for biomedical applications are presented. Owing to its biodegradable nature, magnesium is a promising candidate for temporary implants. However, its rapid corrosion, resulting in excessively high pH levels in the surrounding medium that can induce cell death, remains a major obstacle to its widespread clinical use.To overcome these limitations and provide controlled degradation with enhanced biological functionality, ceramic coatings were developed by PEO using electrolytes enriched with calcium, phosphorus, and silicon, supplemented with naturally derived feedstocks such as eggshell powder. Particular emphasis was placed on improving corrosion resistance, promoting bioactivity and osteoconductivity, and imparting antibacterial functionality to magnesium-based substrates. The effectiveness of the developed coatings was evaluated based on improved corrosion resistance, biological performance, and compatibility with host tissues, alongside the ecological sustainability of the processing routes.

The research was divided into four main stages. In the first stage, the influence of silicate concentration and applied voltage on coating morphology, uniformity, corrosion resistance, and bioactivity was investigated. The second stage focused on the incorporation of silver nanoparticles into silicate-based electrolytes to introduce antibacterial properties while maintaining anticorrosive performance. The third stage concerned the application of combined silicate–phosphate electrolytes to obtain oxide layers with enhanced corrosion resistance and improved cell adhesion. In the fourth stage, phosphate electrolytes containing calcium-based particles, including biowaste-derived components (eggshells), were employed to form coatings enriched with Ca and P, mimicking bone mineral composition and supporting osteointegration with enhanced corrosion resistance.

The obtained coatings were comprehensively characterized in terms of surface morphology, elemental composition, thickness, and wettability. Immersion tests and ion release studies confirmed the influence of processing parameters on the degradation behavior of both the

coatings and the magnesium substrate. Biological assays included cell viability and bacterial adhesion tests.

This research demonstrated the feasibility of producing multifunctional PEO coatings on magnesium using both conventional electrolytes and sustainable additives, including silver nanoparticles and naturally derived materials. Silver-containing systems exhibited successful incorporation of Ag particles during the PEO process and demonstrated antibacterial effects. Layers obtained from silicate–phosphate electrolytes displayed corrosion resistance and controlled ion release. Coatings fabricated in calcium–phosphate electrolytes, particularly alkaline hexametaphosphate systems enriched with eggshell powder, supported cell adhesion and metabolic activity through a favorable Ca/P ratio and adequate porosity.