Innovative hydroxyapatite-based coatings for bone implants: A multifaceted approach

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INTRODUCTION: Tissue engineering strives for innovative solutions in addressing challenges associated with contemporary bone tissue implants. This study focuses on the electrophoretic deposition (EPD) of hydroxyapatite-based bioceramic composites containing antibacterial agents onto titanium surfaces. Two composite coatings, hydroxyapatite/chitosan (HAP/CS) and hydroxyapatite/chitosan/gentamicin (HAP/CS/Gent) were developed to combat issues such as poor adhesion, limited antibacterial potential, limited bioactivity, and potential toxicity of implant materials [1].

EXPERIMENTAL: EPD was performed at constant voltage (5 V, 12 min) on pure Ti plates from aqueous (HAP/CS and HAP/CS/Gent) suspensions. The uniformity and functionality of the deposited coatings were assessed through comprehensive physico-chemical characterization using X-ray diffraction (XRD) (*Philips PW 1710, Netherlands*) and scanning electron microscopy (SEM, Hitachi S-4700, J) equipped with energy dispersive X-Ray spectroscopy (EDS, X-Max, Oxford Instruments, UK). Antibacterial activity was evaluated against *Staphylococcus aureus* TL and *Escherichia coli* ATCC 25922 by quantitatively monitoring changes in the viable number of bacterial cells in suspension. Cytotoxicity against MRC-5 and L929 cell lines was investigated using trypan blue dye-exclusion test (DET) and MTT assay for assessing cell metabolic activity. Statistical significance was determined for antibacterial and cytotoxicity results by one-way analysis of variance (ANOVA), followed by multiple comparisons post-hoc test.

RESULTS AND DISCUSSION: XRD revealed broadened diffraction maximums corresponding to fine HAP crystallites. Porous surface with homogeneously distributed spherical HAP agglomerates embedded in wax-like polymers' matrix of CS was observed for both coatings by SEM. The addition of gentamicin significantly enhanced the antibacterial activity of the HAP/CS/Gent coating – complete reduction of *S. aureus* bacterial cells was achieved within 1 h of exposure. MTT and DET tests indicated low cytotoxicity against MRC-5 and L929 tested cell line for both samples. Slightly decreased cell percentage viability due to gentamicin presence was observed for HAP/CS/Gent.

CONCLUSIONS: Single-step EPD yielded antibacterial composite coatings with potential for biomedical applications. HAP/CS/Gent showed successful gentamicin loading, favorable crystalline structure, and strong antibacterial effects. The presence of fine HAP crystallites yielded a larger surface area, favorable for new bone growth and improved osseointegration. HAP/CS/Gent exhibited good antibacterial activity against both tested bacteria (especially pronounced against *S. aureus* – bactericidal effect), while preserving low cytotoxicity, indicating the high potential for biomedical applications.

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