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Abstract

Development of Magnetic Chitosan Scaffolds with Potential for Bone Regeneration and Cancer Therapy †

Joana Gonçalves , Paula Ferreira and Cláudia Nunes *

CICECO—Aveiro Institute of Materials, Department of Materials and Ceramic Engineering, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal; joanadfgoncalves@ua.pt (J.G.); pcferreira@ua.pt (P.F.)

* Correspondence: claudianunes@ua.pt

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There is a high demand for the development of new strategies to treat malignant bone tumors and to regenerate bone defects produced by tumor resection. Based on bone tissue engineering (BTE), novel multifunctional bioactive 3-D scaffolds, that can simultaneously address the regeneration of bone defects and eradicate residual cancer cells, are a potential approach to fulfill this urgent need.

In this study it was proposed to develop magnetic chitosan-based scaffolds with potential to simultaneously promote bone regeneration and kill residual cancer cells by thermal hyperthermia. Chitosan was selected as the main matrix due to its suitable properties for BTE, such as biocompatibility, antibacterial, and osteogenic behaviour [1]. However, it possesses poor mechanical properties, having a low elastic modulus [2]. Therefore, in our experiments, magnetite nanoparticles (Fe_3O_4 NP) were incorporated in the chitosan matrix to achieve several purposes: (1) to increase the scaffold mechanical strength, (2) to potentiate osteogenesis, and (3) to be used as heat mediators in magnetic hyperthermia therapy (MHT) for cancer treatment. With these purposes, the scaffolds were produced with different chitosan concentrations (1, 1.5, 2 and 2.5% w/v). The effect of NP incorporation on the scaffold properties was also assessed. The freeze-drying technique enabled production of highly porous scaffolds (porosity > 80%) which meet the required porosity for BTE applications. Scaffold porosity decreased as chitosan concentration increased. Porosities of around ~95% and ~83% were achieved for chitosan at 2 and 2.5% w/v respectively. Scaffolds with 2.5% w/v chitosan had the highest Young's modulus and enhanced toughness, indicating that reducing the porosity improved the mechanical response. Spherical Fe_3O_4 NP (9 nm), synthetized by co-precipitation with a specific loss power of 98 W/g, were incorporated (10% w/w) in the 2% w/v chitosan matrix without affecting the scaffold porosity. Furthermore, the mechanical properties were significantly improved, with an increase from 0.68 to 1.08 MPa in the Young's modulus and from 16.5 to 23.3 MPa for toughness, compared to pristine chitosan scaffolds.

Overall, these results confirm the ability to produce highly porous scaffolds, containing 10% w/w of Fe_3O_4 NP, with suitable mechanical properties and porosity by freeze-drying. These properties support proposing chitosan scaffolds with Fe_3O_4 NP for BTE.

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