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Abstract

Multifunctional Sintering-Free Composite Scaffolds Developed by Additive Manufacturing †

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Robocasting (also called direct-write assembling) is an additive manufacturing technology based on the extrusion and deposition of an ink, layer by layer, that has been explored for the manufacture of architectural and compositional 3D porous structures with high precision and reproducibility for bone tissue regeneration. The mechanical integrity of the bioceramic-based scaffolds is commonly obtained by sintering (heat treatment usually above 1000 °C) which precludes the incorporation of bioactive molecules before this step.

The main goal of the present work was the manufacture of multifunctional composite scaffolds by robocasting, suppressing sintering as a post-printing process. The abolition of this step leads to the design of inks comprised by calcium-phosphate-based particles, drugs and/or magnetic particles follow-on in scaffolds with multiple therapy functions as local drug delivery, cancer treatment by hyperthermia and bone tissue regeneration. Natural polymeric aqueous-based solutions of chitosan and/or chitosan/silk fibroin with different ratios were used as a base matrix. The multifunctional inks were characterized by rheological studies in viscometry and oscillatory modes, these being the printable ones selected to produce scaffolds with different macropore sizes (300 µm and 500 µm). The inks allowed the fabrication of customizable 3D structures with interconnected pores, able to carrier drugs and/or to respond to an external magnetic field. The mechanical strength and rigidity were achieved through the crosslinking of the system and the amounts of bioceramics in the composition. The scaffolds were characterized by mechanical performance, magnetic behavior, morphological features, degradation rate and biological studies.

The developed sintering-free composite scaffolds represent a strong potential to be applied as bone substitutes. Furthermore, the advances of the evaluated work are opening promising paths for future progresses in materials science and the tissue engineering area.

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