Enhanced Osteointegration and Antimicrobial Functionality in Porous Ti6Al4V Scaffolds Fabricated via SLS

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Bone-related injuries and pathologies have increased during the last years; consequently, the number of surgeries for addressing these conditions [1]. In case of severe damage, such as comminuted fracture, fillers are commonly used [2]. The metallic implants are the gold standard. In this context, Ti6Al4V is one of the most employed due to its strength and biocompatibility [3]. However, to overcome the issues presented by high stiffness and low bioactivity, the use of porous designs arises as a suitable strategy. This study developed 3D-printed porous Ti6Al4V scaffolds by Selective Laser Sintering (SLS), and enhanced biofunctionality through bioactive polymeric infiltrations.
Scaffolds were fabricated using SLM, varying filament distances (0.1–0.5 mm) to achieve customized porosity. Morphological characterization included Optical Microscopy (OM), Scanning Electron Microscopy (SEM), and Laser Scanning Confocal Microscopy (CLSM). Biofunctionalization was achieved by infiltrating the scaffolds with biopolymeric composites reinforced with 45S5 bioglass (BG) and silver nanoparticles (AgNPs). Additionally, Finite Element Method (FEM) simulations were performed to estimate load distribution and strain under physiological stresses. The bioactivity and antimicrobial efficacy of the scaffolds were studied *in vitro* through bacterial colonization and apatite formation tests.
Results demonstrated that infiltration significantly enhanced scaffold bioactivity, with notable apatite formation and a reduction in bacterial adhesion compared to bare scaffolds. Furthermore, the FEM simulation indicates that the scaffold will stand under physiological stresses. These findings highlight the potential of porous, biofunctionalized Ti6Al4V scaffolds to address clinical challenges in bone repair by providing tailored mechanical support, compatibility with bone stresses, and enhanced bioactivity.

References

[1] S.P. Ryan, J.B. Stambough, J.I. 3rd Huddleston, B.R. Levine, Arthroplast Today, 26 (2024), 101325.
[2] K.A. Egol, A. Nauth, M. Lee, H.C. Pape, J.T. Watson, J. Jr. Borrelli. J Orthop Trauma, 29 (2015), S10-14.
[3] A.M. Khorasani, M. Goldberg, E.H. Doeven, G. Littlefair. J Biomater Tissue, 5 (2015), 593-619.

Figures

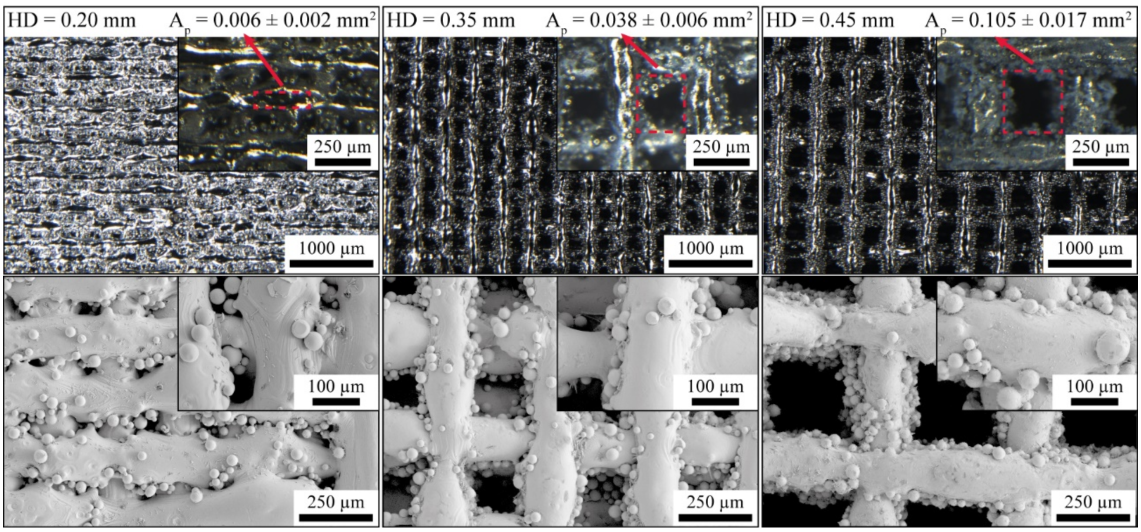

Figure 1: Effect of the hatch distance modification on 3D-printed porous Ti6Al4V scaffolds by SLS, observed in low magnification top-view perspective images (a-c) and SEM images (d-f).