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Functionalization of 3D-printed β-TCP scaffolds with palmarosa essential oil

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Introduction

❖ Critical-sized bone defects are susceptible to bacterial infections, highlighting the need for local antimicrobial strategies[1,2].

❖ β-Tricalcium phosphate (β-TCP) is a biocompatible, osteoconductive, and bioresorbable ceramic widely used in bone tissue engineering scaffolds[1,2].

❖ Palmarosa essential oil (PEO) is rich in geraniol (68–84%) and exhibits antibacterial, antioxidant, and anti-inflammatory properties[3].

Objective

❖ This study aimed to develop and characterize 3D-printed β-TCP scaffolds fabricated by Direct Ink Writing (DIW), followed by functionalization with gelatin coating containing PEO (5 and 10 vol.%).

Methodology

1. β-TCP Synthesis
Solid-state reaction (CaHPO4 and CaCO3 - 1050 °C/6 h)

2. 3D Printing via Direct Ink Writing
Cylindrical geometry (Ø12 mm × 5 mm), 40% infill, and 0º/90 grid

3. Sintering
Drying at RT (24 h), organic debinding (500 °C/1 h), and sintering (1200 °C/2h)

4. Functionalization
Dip-coating for 3 min in 2.5 wt% gelatin loaded (5 and 10 vol.% PEO)

5. Characterization
SEM, FTIR, compressive strength testing, and biological assays in vitro

Results and Discussion

❖ The scaffolds exhibited 54% porosity and a compressive strength of 3.75 MPa. SEM confirmed structural fidelity and a well-defined porous architecture (Figure 1), while FTIR confirmed successful PEO coating on β-TCP scaffolds (Figure 2). Antibacterial tests demonstrated effective inhibition against E. coli and S. aureus (Figure 3).

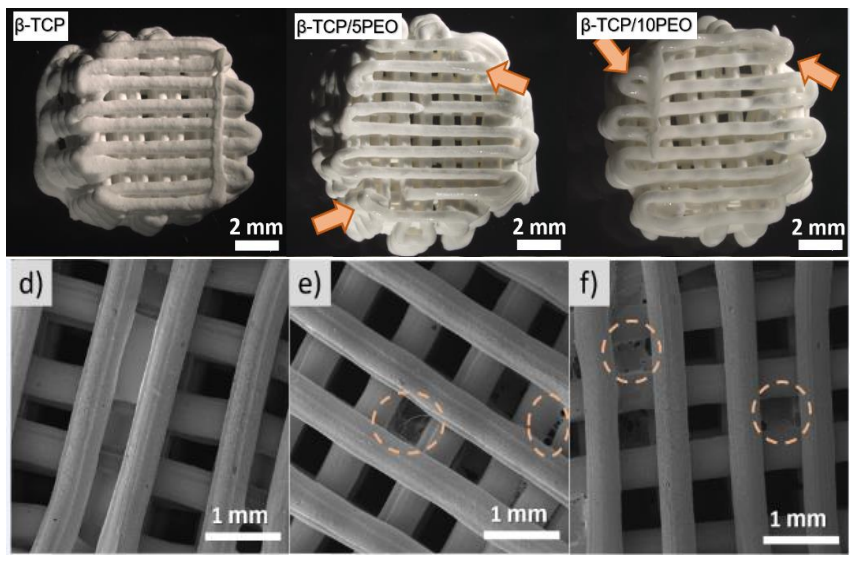


Figura 1. Stereomicroscopy and SEM images.

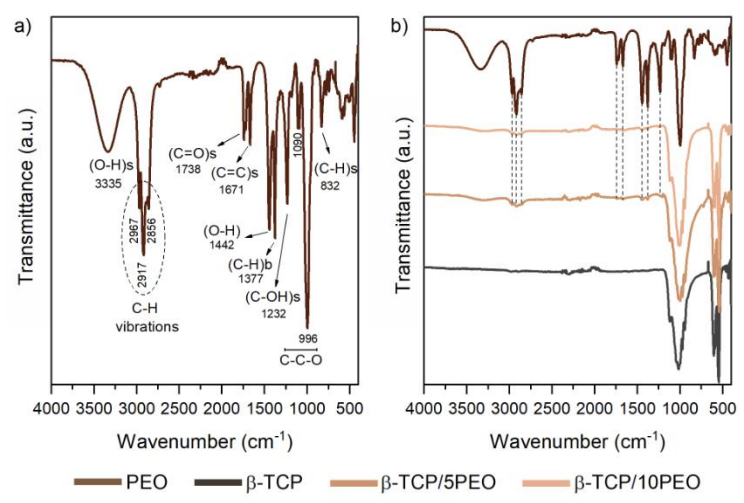


Figura 2. FTIR spectra of (a) PEO, and (b) β-TCP/PEO scaffolds.

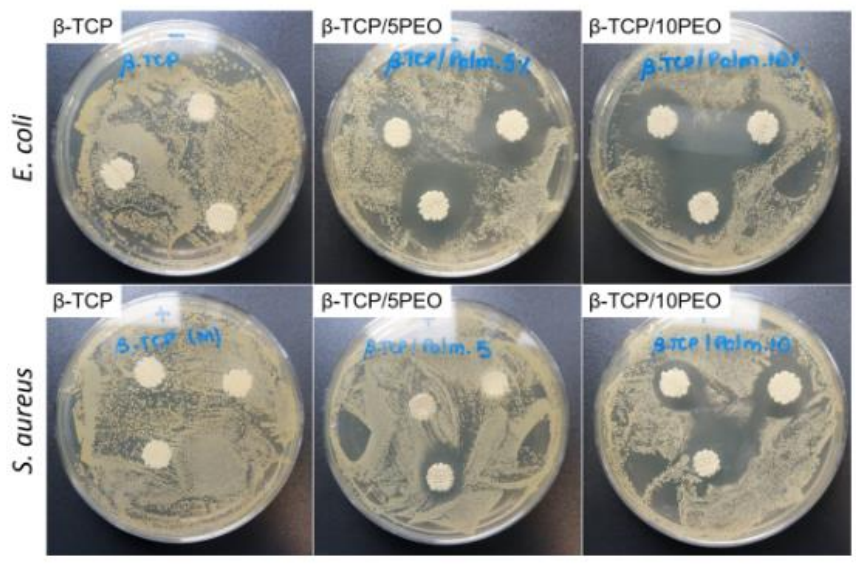


Figura 3. Images of agar plates.

Conclusions

❖ We successfully functionalized 3D-printed β-TCP scaffolds with PEO coating, which exhibited antibacterial activity against both microorganisms, highlighting their potential as multifunctional, antibiotic-free bone graft substitutes.

References

1. Appuhamillage GA, Ambagaspitiya SS, Dassanayake RS, et al. Explor Med. 2024;5:17–47. DOI: 10.37349/emed.2024.00203. 2. Nayak VV, Slavin BV, Bergamo ETP, et al. Tissue Eng. Part C: Methods. 2023;29(7):332-345. DOI:10.1089/ten.tec.2023.0082. 3. Raina, V.K., Srivastava, S.K., Aggarwal, K.K., et al. Flavour Fragr. J. 2003;18: 312-315. DOI: 10.1002/ffj.1222.

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