

Development and biological *in vitro* study of three-dimensional printed poly(lactic acid) scaffolds coated with gelatin-based coaxial nanofibrous coatings for bone repair

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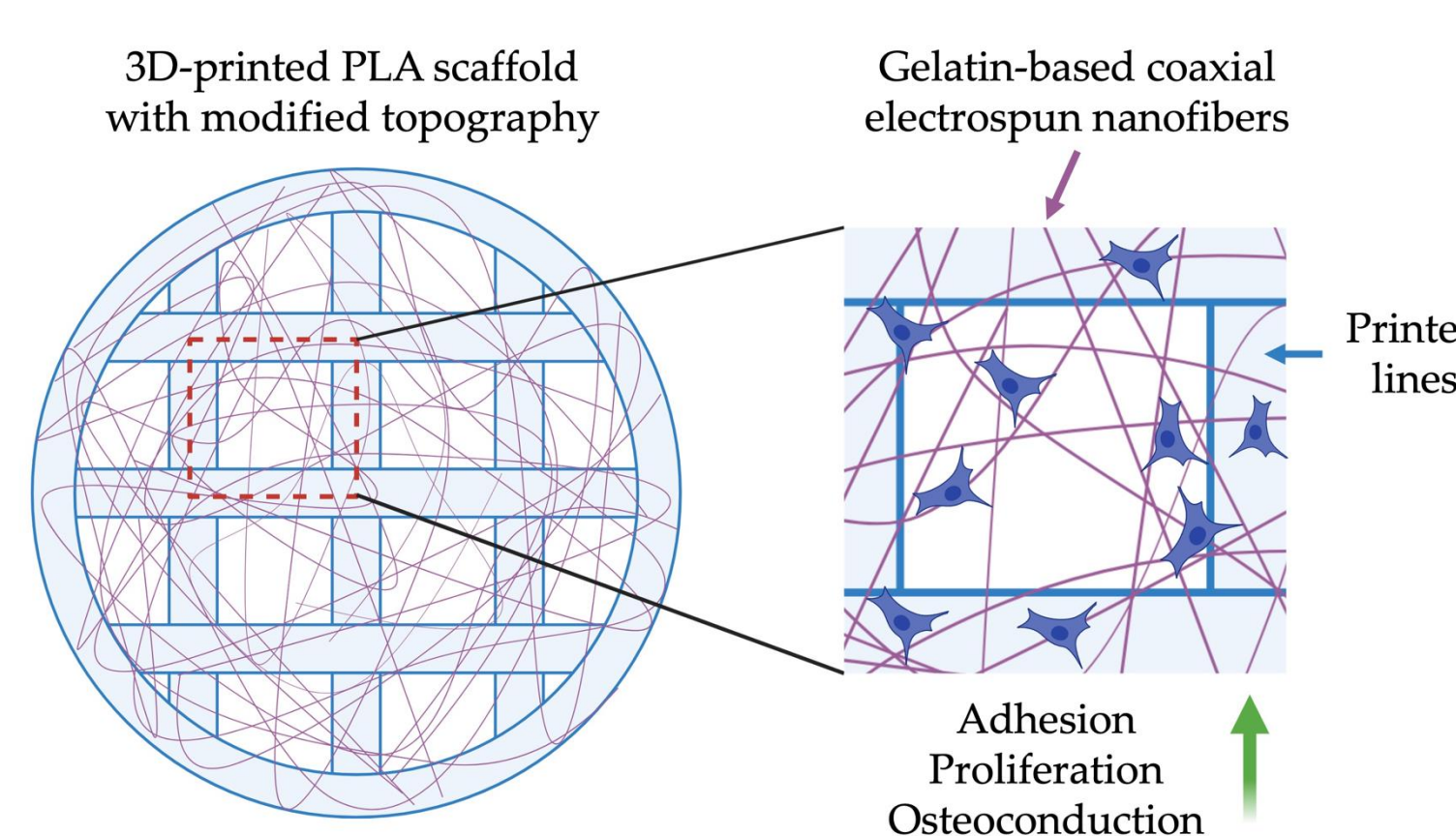
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INTRODUCTION & AIM

Bone grafting has been a challenge in recent decades, primarily because the "gold standard" methods, such as autografts, have low bioavailability and pose a risk to the donor site [1]. Therefore, there still remains a focus on developing biocompatible polymer-based biomaterials as a scaffolds for bone restoration [2]. Three-dimensional (3D) printing is a revolutionary technology for scaffold manufacturing. However, material extrusion printing remains limited by the resolution and smooth surface formation, which affects cell adhesion, proliferation, and subsequent bone restoration [3]. This work focuses on the study of the effect of the biological behavior of gelatin/polyester-based coaxial nanofibrous (CNF) coatings on 3D-printed poly(lactic acid) (PLA) scaffolds.



Graphical abstract. Schematic representation of biological enhancement behavior of the 3D-printed PLA scaffolds coated with gelatin-based coaxial nanofibers for bone tissue engineering applications.

METHODS

1. Manufacturing of 3D-printed scaffolds coated with nanofibers

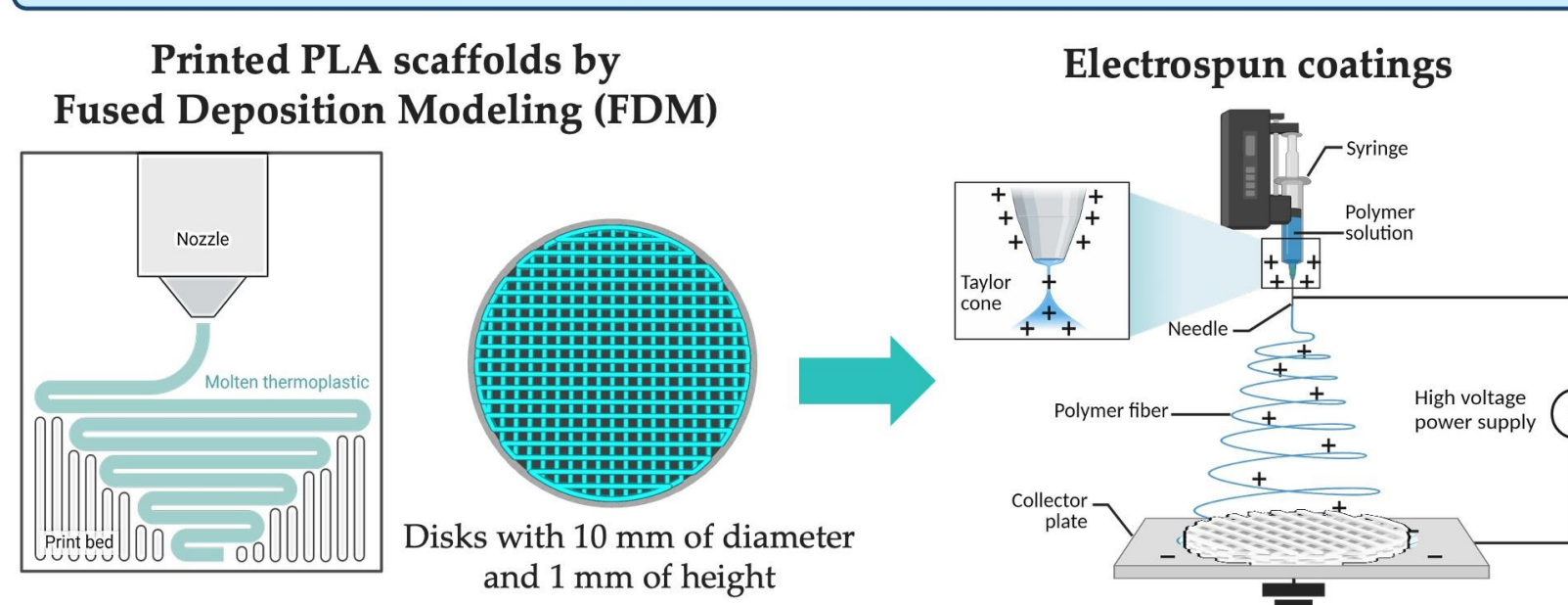
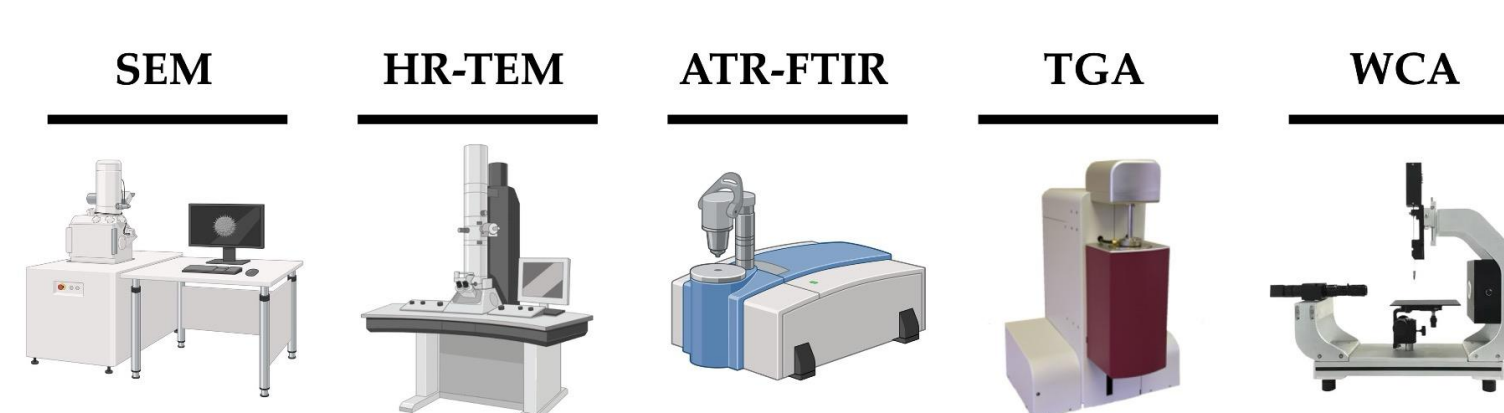


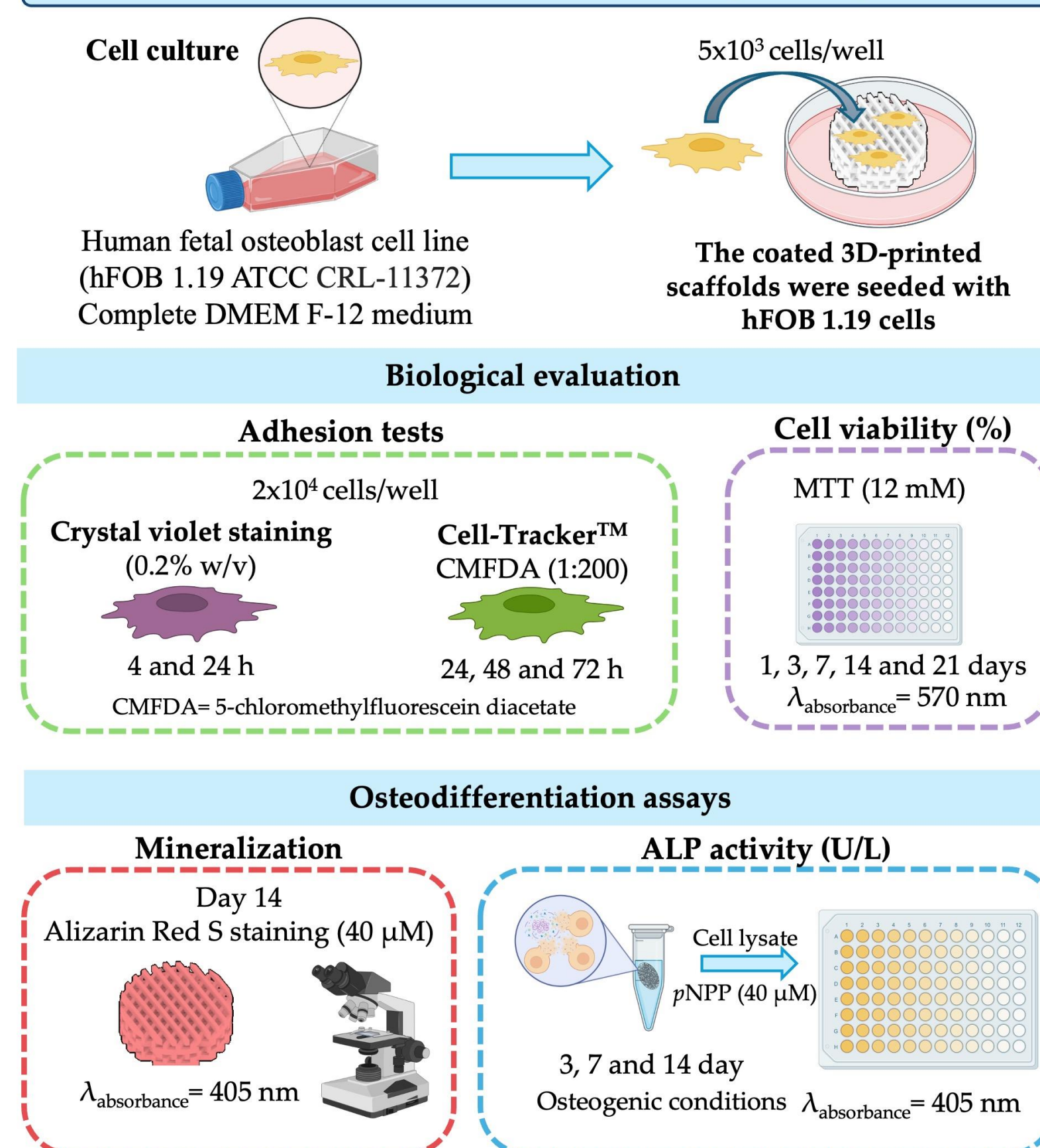
Table 1. Electrospinning parameters for nanofibrous coatings fabrication.

ES Parameters	Single-Nozzle Gelatin, PCL or PLA	Coaxial PCL or PLA/Gelatin
Flow Rate (mL h ⁻¹)	0.5	0.2 (Core)/0.5 (Shell)
Voltage (kV)	10	10
Distance (cm)	14	14

2. Physicochemical characterization



3. *In vitro* evaluation of the biological response



RESULTS & DISCUSSION

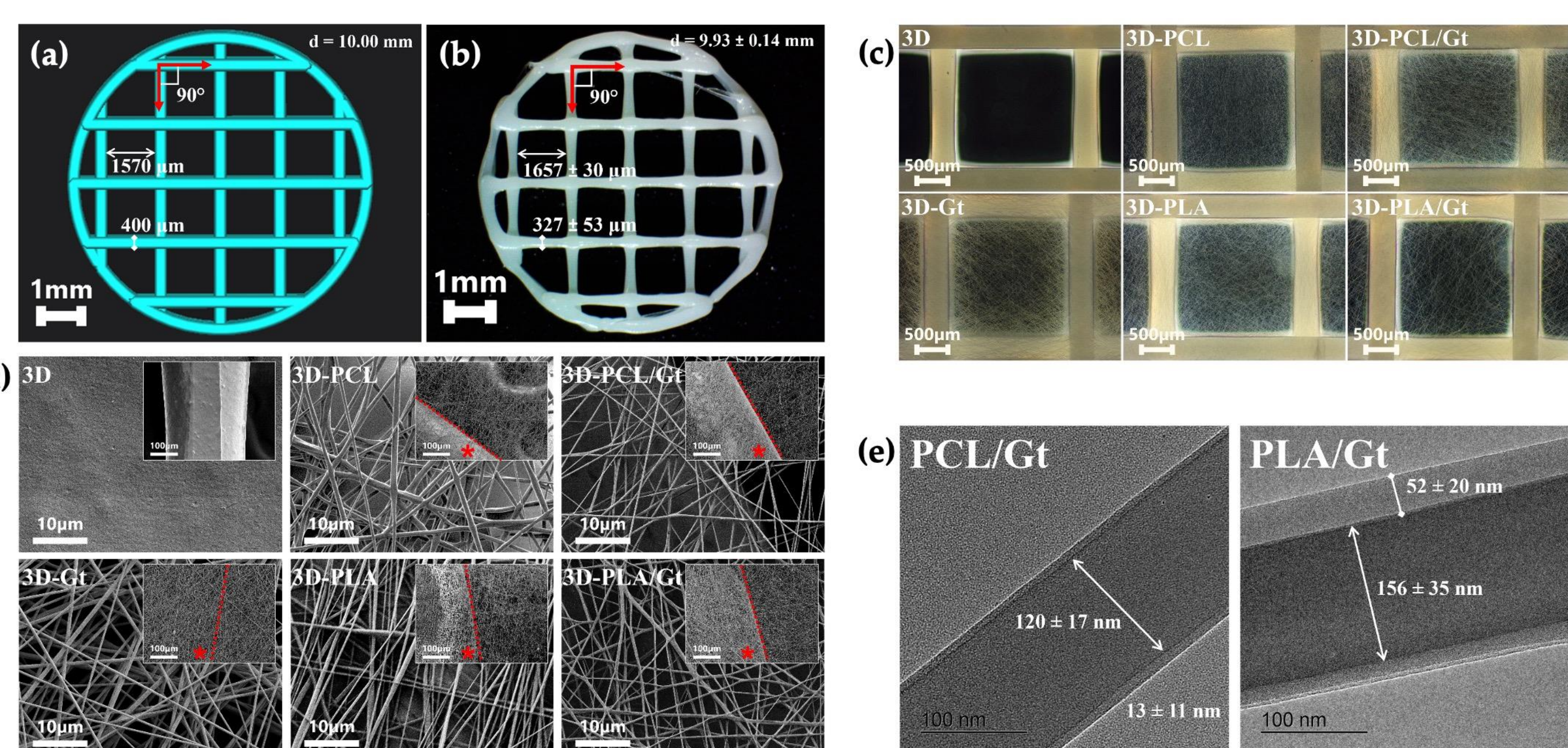


Figure 1. Manufacturing of 3D-printed PLA scaffolds coated with nanofibers. (a) STL model (10 mm in diameter and 1 mm in height with 80% of porosity). (b) Comparison of 3D-printed PLA disk with the STL model. (c) Dark-field micrographs of 3D-printed with electrospun nanofibrous coatings. (d) SEM images of the interfacial surface of the 3D-printed scaffolds coated with nanofibrous. (e) TEM images for gelatin-based coaxial electrospun nanofibers with core-shell structure.

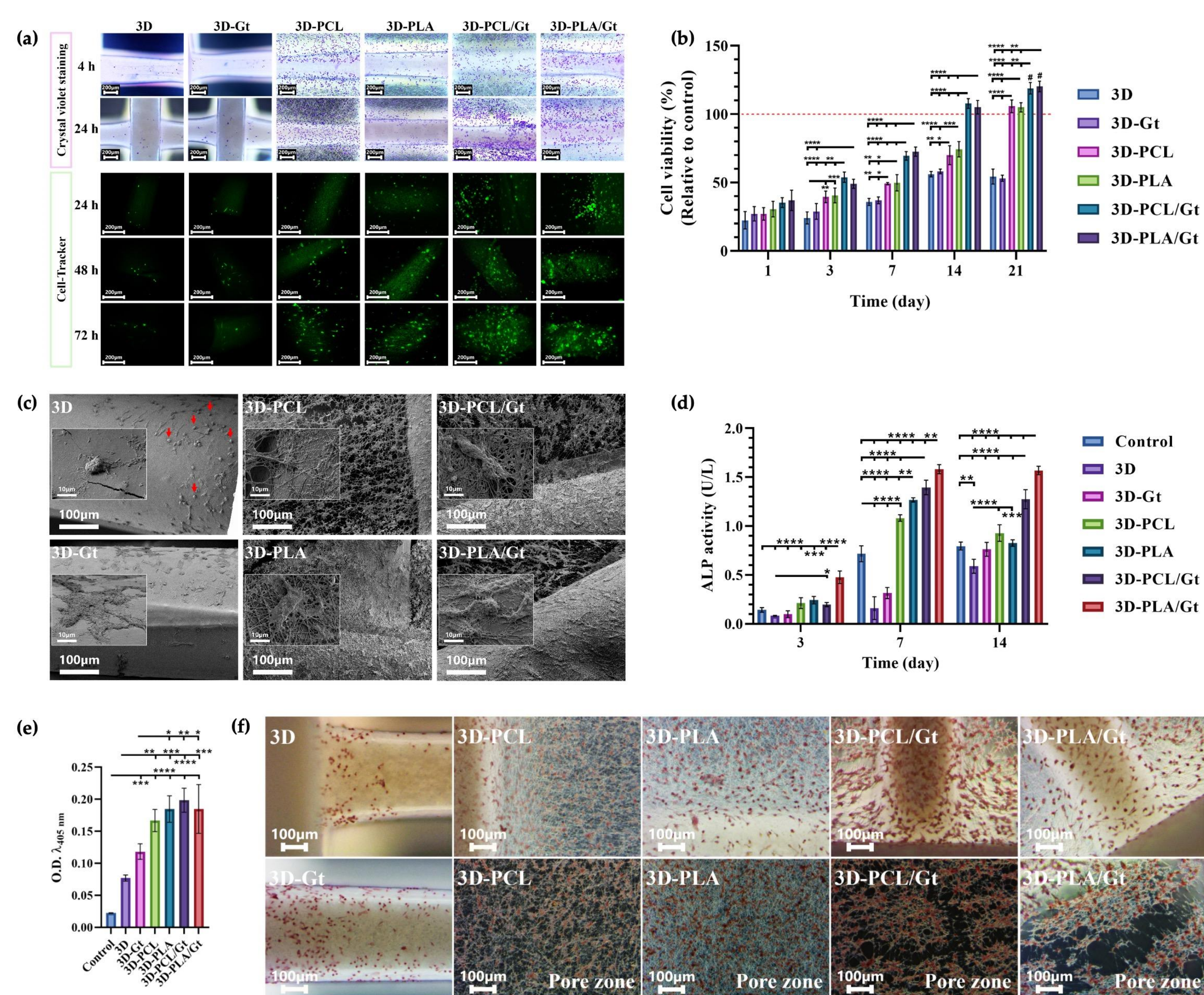


Figure 3. *In vitro* evaluation of biological response of 3D-printed PLA scaffolds cultivated with hFOB 1.19 cell line. (a) Adhesion tests with crystal violet staining and Cell-Tracker. (b) MTT assay for cell viability (%) evaluation. (c) SEM images of cells interaction with the coated 3D-printed scaffolds at day 14. (d) Alkaline phosphatase activity (U/L) of cultivated cells into 3D-printed scaffolds. (e) Alizarin Red S staining measurement and (f) calcium deposition images of the surface of 3D-printed scaffolds. Two-way ANOVA and Tukey's *post-hoc*. **p*<0.05, ***p*<0.01, ****p*<0.001, *****p*<0.0001 and #*p*<0.0001 vs. the control.

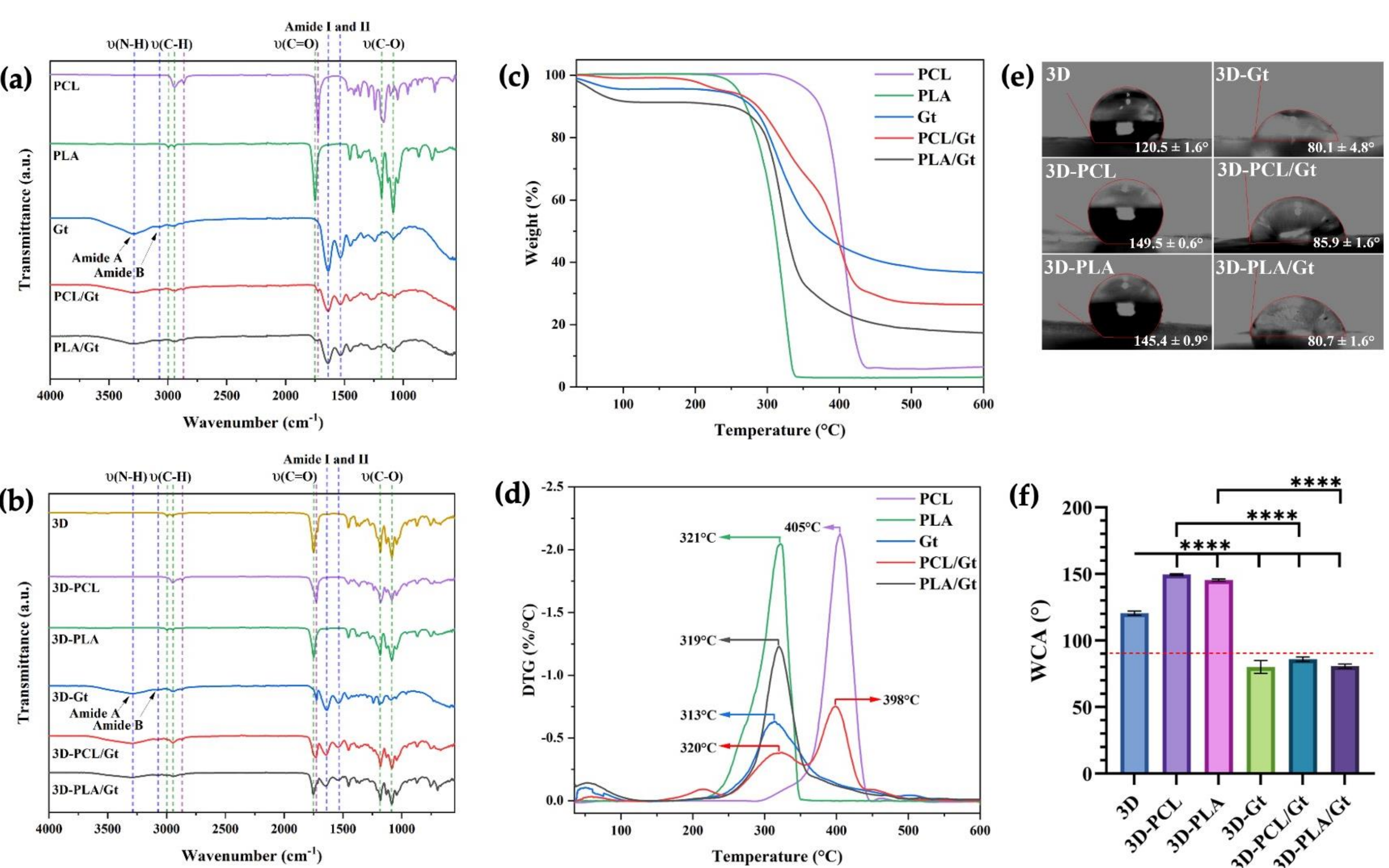


Figure 2. Characterization of 3D-printed scaffold coated with nanofibers. (a) Infrared spectra of electrospun nanofibers and (b) 3D-printed PLA scaffolds with nanofibrous coatings. (c) Thermogravimetric analysis and (d) DTG of electrospun nanofiber coatings. (e) Water contact angle (WCA) test and (f) measurement comparisons for 3D-printed PLA scaffolds coatings with nanofibers. One-way ANOVA and Tukey's *post-hoc*. **p*<0.05, ***p*<0.01, ****p*<0.001, *****p*<0.0001.

ACKNOWLEDGMENT

CET-S acknowledges for the scholarship support from SECIHTI for his Ph.D. studies (CVU:1009583). The authors want to thank to the financial support given by the DGAPA-UNAM-PAPIIT IN106624, IN218223, and IN202924, and PAIP-FQ 5000-9222 projects.

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