DNIETOLAB
Tissue and Organ Engineering
ADVANCED BIOFABRICATION LABORATORY

CICA CENTRO INTERDISCIPLINAR DE QUÍMICA E BIOLOXÍA

UNIVERSIDADE DA CORUÑA

AI-Driven Multimaterial Digital Light Processing for Multiscaled and Multimaterial Vascular Tissue Constructs

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Engineering functional vasculature remains a key bottleneck in tissue engineering, as construct thicker than 1mm require efficient vascular networks to ensure cell viability and sufficient nutrient transport. Conventional 3D bioprinting methods face trade-offs between resolution, scalability, and biomimetic fidelity.

Light-based bioprinting approaches, including SLA, VBP, and DLP, offer superior resolution and geometric control, along with the ability to fabricate heterogeneous, cell-laden constructs. However, challenges persist in achieving sufficient mechanical integrity, long-term cell viability, scalability, and efficient photopolymerization in thick tissues.

Recent advances in AI-driven, multimaterial DLP systems provide new opportunities to improve printing accuracy, material control, and fabrication of complex vascular architectures.

Objective: Evaluate whether an AI-driven multimaterial DLP platform enables the one-step fabrication of multiscale vascular structures with high geometric fidelity and cell viability, overcoming current limitations in resolution, heterogeneity, and scalability.

Custom AI-driven DLP Multimaterial Bioprinter

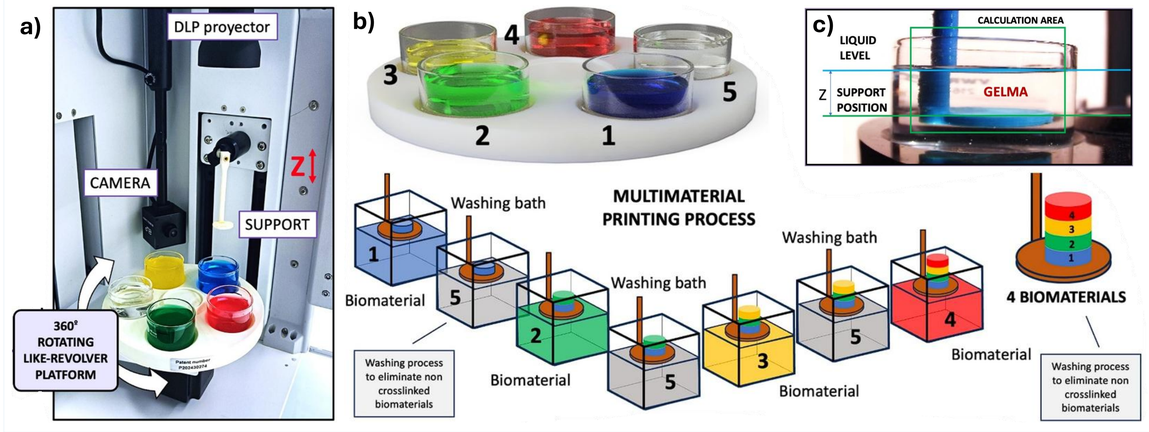


Figure 1. a) Image of the printing are showing the key printing components with b) a diagram of the multimaterial printing and c) a diagram of the "Top-down" DLP printing process.

Experimental data

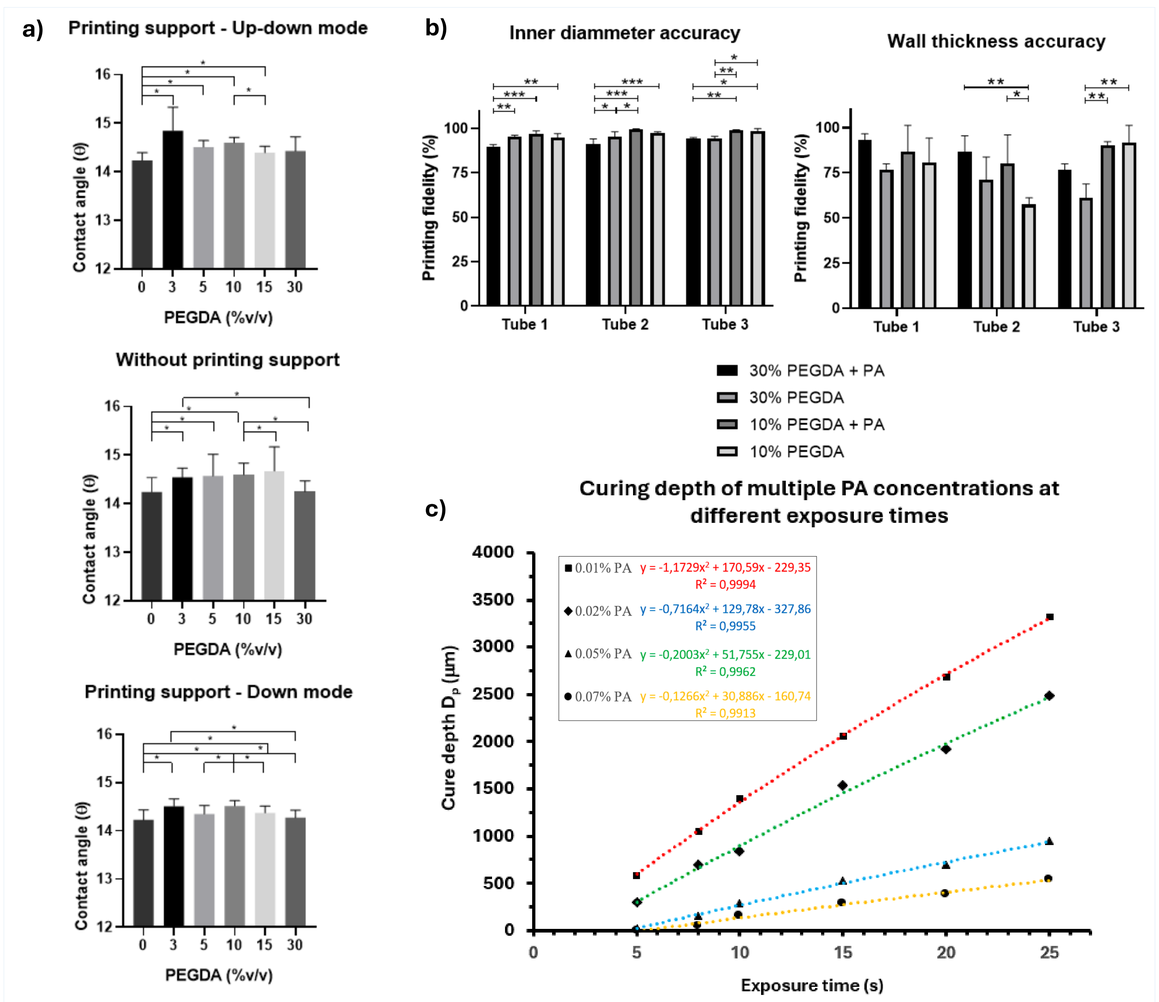


Figure 2. a) Ink's contact angle variability with the printing vat under three different printing configurations and different PEGDA concentrations. b) Printing accuracy of both (left) inner diameter and (right) wall thickness on hollow tubular structures of different scales obtained after printing models with different diameters. *: $p < 0.05$. c) Curing depth curves obtained for inks with different photoabsorber (PA) concentration.

3D printing tests

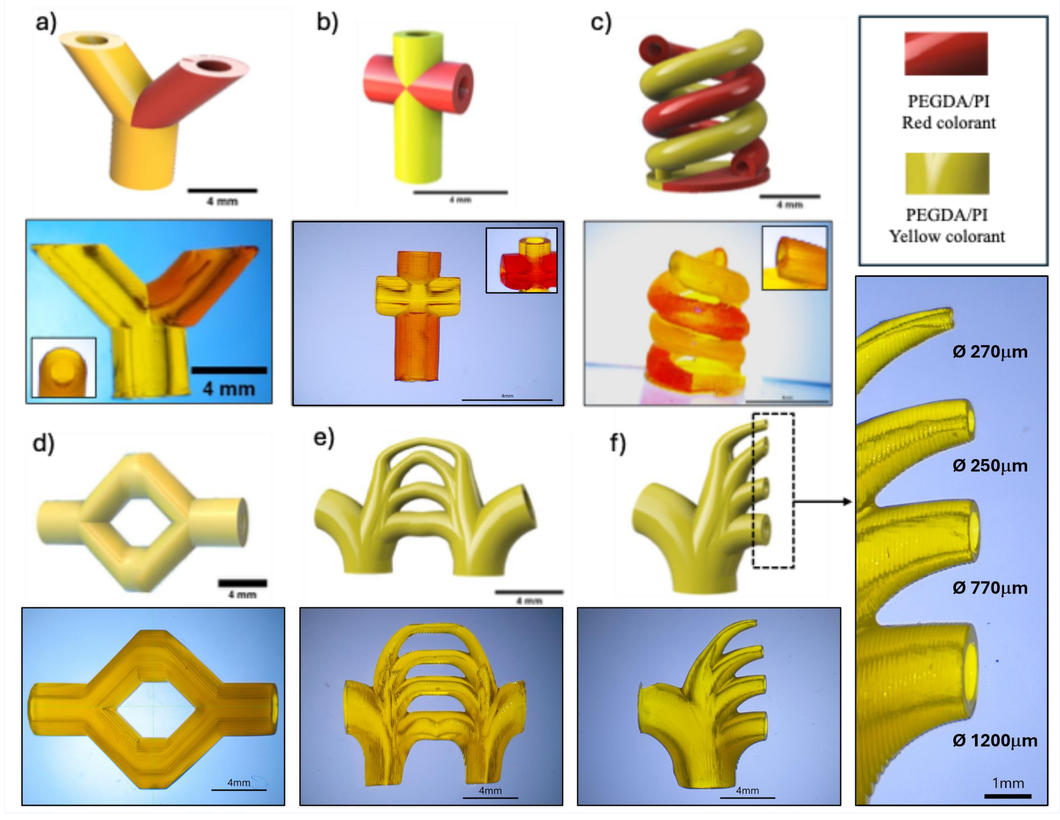


Figure 3. CAD models and corresponding printed structures used to evaluate the system's multimaterial printing performance. a) **Y-shaped bifurcated model** with branches in a different material. b) **Diamon-loop channel** with continuous hollow channel along bifurcations. **c) Cross-shaped structure** with A-B-A configuration. **d) Open vascular like bifurcations**, with hollow multiscale channels. **e) Hollow double-helix spiral** with each helix printed in a different material. **f) Closed vascular like bifurcations**, with superimposed hollow channels retaining vertical spacing. Detail of the approximate inner diameter achieved in each bifurcation (right).

3D printing multiscale vascular structures

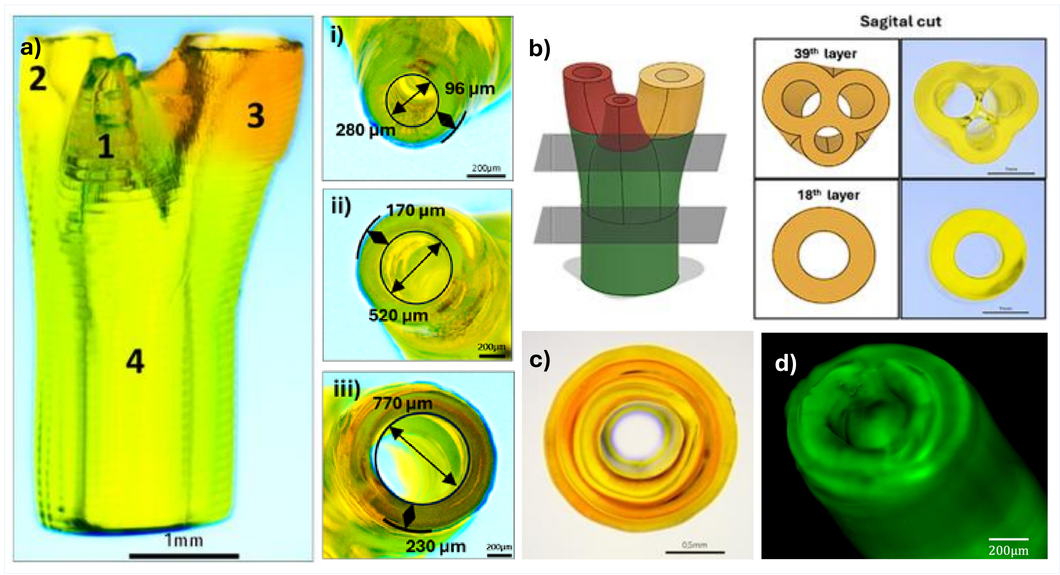


Figure 4. a) (Left) 3-armed vascular-like structure CAD design with inner lumen dimensions, with the printed multimaterial construct achieved and details of the i) tube 1, ii) tube 2 and iii) tube 3. b) Schematic illustration of the layer height where the printing process was stopped for the 3-armed vascular-like model and (right) the resulting construct sagittal view showing a completely hollow structure. c) Multilayered hollow tube with multimaterial concentrical layers in an approach to vessel wall layers. d) Fluorescence image of the oblique view of a smaller multilayered hollow tube.

Cell bioprinting

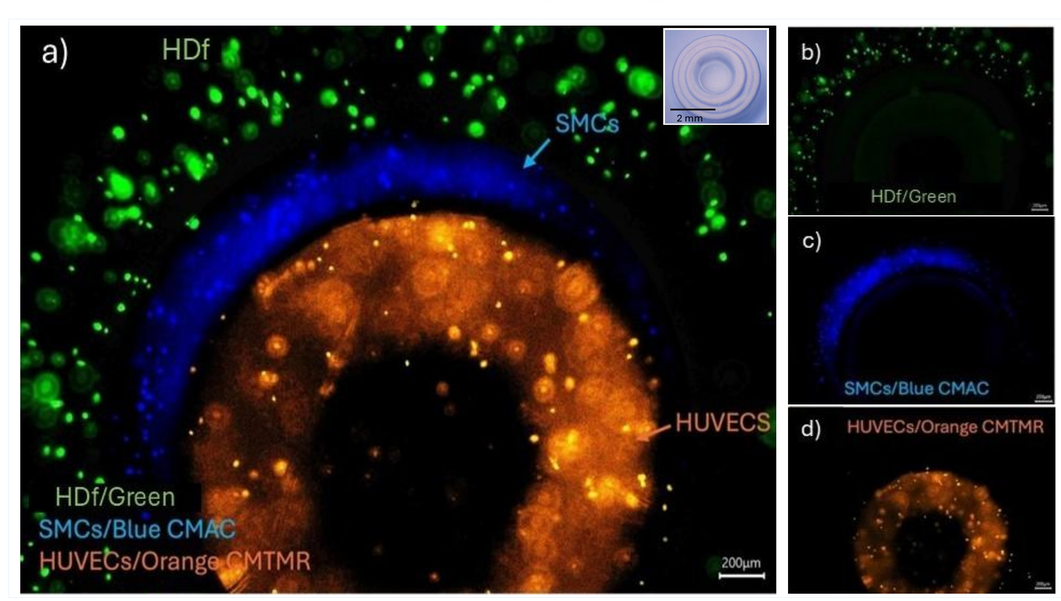


Figure 5. Multimaterial bioprinted tubular structure. a) Fluorescence image showing the three cell-laden structure with encapsulated cells: b) Fibroblasts (green), c) Smooth muscle cells (blue), and d) Endothelial cells (orange) within the 3D construct at 24h post-printing.

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