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An evaluation of bio-inspired patterns for soft tissue-mimicking with multi-material 3D-printing

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Thanks to multi-material Additive manufacturing (AM), it is nowadays possible to mimic the mechanical behavior of complex biological soft tissues. This enables, e.g., to experiment with novel implantable devices or surgical procedures in a non-risk setting. In a recent work [1], the authors considered four bio-inspired patterns: Tendon-Like (TL), Tendon-Mimic (TM), Bamboo-Like (BL), and Helix-Bamboo (HB). Multi-material dog-bone specimens (designed accordingly to ASTM Standard D638, Type IV shape) were produced with a Stratasys® J750™ Digital Anatomy 3D Printer (DAP), combining Agilus30™ photopolymers with different Shore A hardness levels in several configurations. These included different matrix-to-fiber ratios, with the internal fibers arranged as complex layered structures (up to three layers). In total, 44 different variants, fully detailed in [1], were considered.

The properties of these specimens (three per variant) were then assessed under uniaxial Ultimate Tensile Strength (UTS) tests, performed at the Laboratory of Bio-inspired Nanomechanics of Politecnico di Torino. An MTS Insight® Electromechanical Testing System, specifically intended for the precise characterization of biological and bioinspired materials, was used, with a 100 N load cell. The results – in terms of stress-strain curves, tensile strength at break, maximum strain at break, and modulus of elasticity – were then compared to the values of the equivalent base PolyJet materials.

These comparisons showed that several patterns improved the mechanical response of the specimen with respect to their mono-material counterparts. For instance, at least one variant per each of the four classes (TL, TM, BL, and HB) returned a higher total deformation for comparable tensile strength. Thus, this work highlighted the potentialities of multi-material AM to integrate different hierarchical and complex shapes into single specimens. This enabling technology will play a decisive role for future biomedical applications, especially for soft tissue (e.g., tendon and ligament) repairing.

AUTHOR'S STATEMENT

Conflict of interest: One of the authors (I.B.) is employee of Stratasys Inc. and O. Grimaldo Ruiz presents the work on behalf of Stratasys Inc. The full paper has been published in Polymers Journal, this article belongs to the Special Issue Structure and Properties of Polymeric Materials in Additive Manufacturing. Published: 28 June 2022. Animal models: not applicable. Informed consent: Informed consent has been obtained from all individuals included in this study. Ethical approval: not applicable. Acknowledgments: The authors would like to thank Stratasys Inc. (Rehovot, Israel) for providing all materials used in this study.

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