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P12. Multidisciplinary

3D-printed stent using biodegradable PCL composite infused with contrast agents for enhanced radiopacity

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Abstract

Continuous in vivo observation of polymer-derived biodegradable stents (BDSs) is important for their efficacious interventions in cardiovascular applications. However, the inherent non-radiopacity of BDSs presents substantive impediments in assiduously observing patient trajectories. Herein, we propose a biodegradable contrast medium which is synthesized by conjugating 2,3,5-triiodobenzoic acid (TIB) with polycaprolactone diol (PCL-diol). The subsequent PCL-TIB is amalgamated with polycaprolactone (PCL) to prepare a polymer framework apt for stent fabrication via additive manufacturing methodologies. The mechanical resilience of the resultant BDSs is appraised via exhaustive evaluations, evidencing their capacity to counter external perturbations and maintain their architectural coherence. Cell viability tests on human umbilical vein endothelial cells (HUVECs) indicate a viability surpassing 90% relative to a control cohort, highlighting the superior biocompatibility and minimal cytotoxicity of the engineered BDSs. Moreover, in vivo radiographic assessment of the BDSs, inclusive of those laden with iohexol, showcased a decline in radiopacity post 7 days, culminating in an indiscernible radiopacity post 9 days. Conversely, BDSs fortified with the proposed degradable contrast medium sustained their radiographic visibility for an interval extending to 40 days. Owing to the excellent biocompatibility and extended radiopacity, the proposed BDSs can be used to address diverse cardiovascular ailments.

Keywords: 3D printing, Biodegradable contrast agent, Radiopacity, Bioresorbable stent

Acknowledgement

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Material characterization and 3D printer fabrication

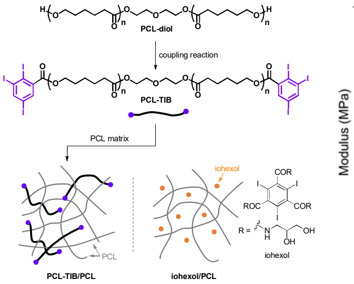

Fig. 1. Schematic illustrates the preparation process flow of the PCL-TIB/PCL hybrid composite and a control Iohexol/PCL composite.

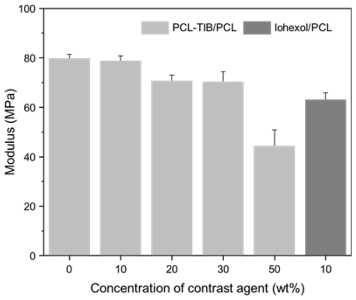

Fig. 2. Change in elastic modulus of the PCL-TIB/PCL hybrid composite according to the weight percentages of the PCL-TIB contrast agent.

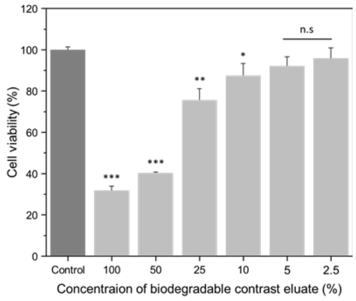

Fig. 3. Cell viability measurements of HUVECs cultured with PCL-TIB contrast agent eluate with different concentration.

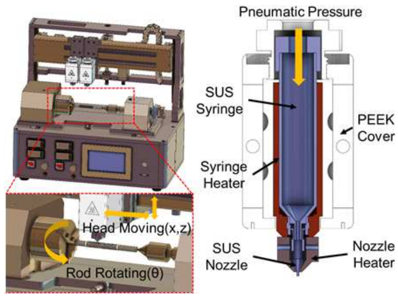

Fig. 4. Schematic diagram of an FDM-type 3D printer for manufacturing biodegradable stents

Characterization of biodegradable stent with contrast medium

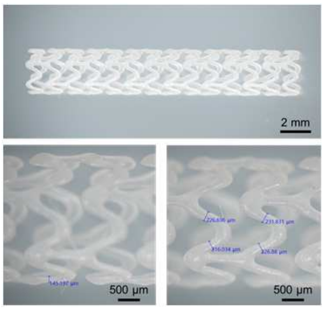

Fig. 5. Optical image of PCL stent with integrated biodegradable contrast agent

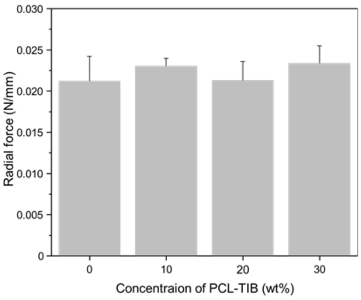

Fig. 6. Bar plots illustrating the radial force exerted by the fabricated BDSs at different concentrations of functional additives.

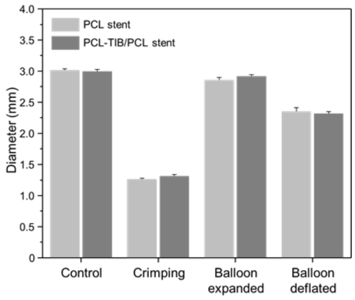

Fig. 7. Bar plots demonstrating the diameter of the fabricated BDSs comparing bare stents with BDSs incorporating 30 wt% of the PCL-TIB.

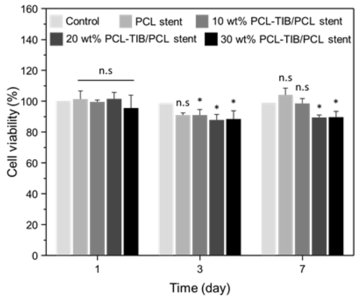

Fig. 8. Cytotoxicity analysis of the fabricated biodegradable stents at different concentration of contrast medium.

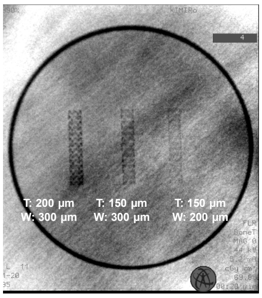

Fig. 9. Visibility of the PCL-TIB/PCL stent under real-time x-ray for in vitro.

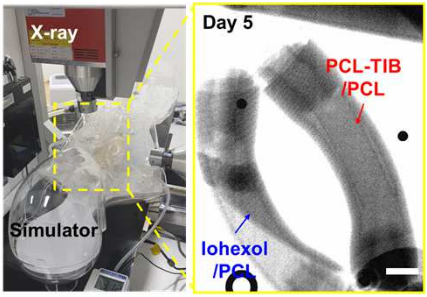

Fig.10. Prolonged x-ray visibility of stents based on 30 wt% PCL-TIB/PCL and 10 wt% Iohexol/PCL in the endovascular evaluator.

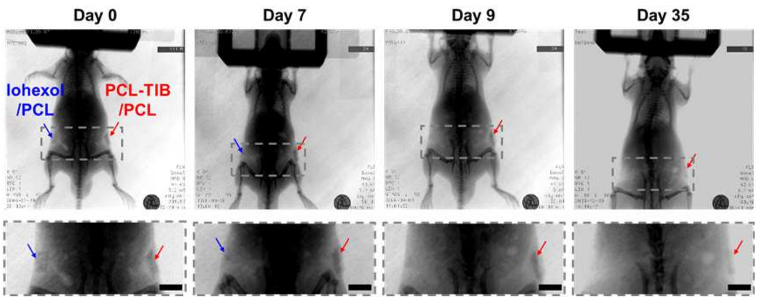

Fig. 11. In vivo prolonged x-ray visibility of stents based on 30 wt% PCL-TIB/PCL and 10 wt% Iohexol/PCL

Conclusion

The aim of this study was to enhance the X-ray visibility and duration of biodegradable polymer stents. To achieve this, a biodegradable contrast medium incorporated PCL composites were synthesized. Subsequently, a stent structure was fabricated 3D printing technology. The PCL composite-based biodegradable stent exhibited no alterations in mechanical stiffness owing to the incorporation of the contrast agent. Furthermore, cell viability analysis using human umbilical vein endothelial cells (HUVECs) demonstrated that over 90% of cells survived, thus confirming biocompatibility. Notably, X-ray visibility persisted for more than 50 days, enabling monitoring post endovascular stent implantation and surgery. Consequently, the PCL composite-based biodegradable stent, featuring the proposed contrast medium, is anticipated to possess significant medical applicability.

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