

EXPLOITATION OF A CUSTOM-MADE THERMOPLASTIC POLY(URETHANE) FOR 3D PRINTING OF ANISOTROPIC CARDIAC SCAFFOLDS

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Poly(urethane)s (PURs) are a versatile class of polymers whose tunable chemistry makes them attractive materials for additive manufacturing (AM) in tissue engineering. In this work, a custom-made thermoplastic PUR was developed, characterized, and processed by melt extrusion additive manufacturing (AM) to obtain anisotropic scaffolds suitable for cardiac tissue modeling.

The PUR was synthesized using poly(ϵ -caprolactone) (PCL) diol, 1,4-butanediisocyanate, and L-lysine ethyl ester as chain extender. Successful synthesis was confirmed by infrared spectroscopy, which showed characteristic urethane bond absorption peaks, and by size exclusion chromatography (SEC), revealing a number-average molecular weight of 49.5 kDa and a polydispersity index of 1.37. Thermal characterization by differential scanning calorimetry and thermogravimetric analysis showed a melting temperature of the PCL soft segments of 57 °C and thermal stability up to 230 °C, confirming the suitability of the polymer for thermoplastic processing.

The processability of the PUR was assessed through melt extrusion AM using a 0.4 mm nozzle at 120 °C. Polymer stability at the printing temperature was verified by post-processing SEC analysis. The fabricated scaffolds exhibited a circular geometry with rhomboidal macroporosities, resulting in an anisotropic architecture designed to better mimic native myocardial structure. The printed filaments showed a diameter of approximately 0.41 mm, indicating good shape fidelity and dimensional stability during the printing process.

To enhance surface bioactivity, the PUR scaffolds were functionalized through plasma-induced acrylic acid grafting, followed by fibronectin immobilization via carbodiimide chemistry. The amount of grafted fibronectin ranged between 25 and 35 μ g per scaffold, demonstrating the effectiveness of the functionalization strategy.

Overall, this work demonstrates that the developed custom-made thermoplastic PUR combines suitable thermal properties, printability, and surface functionalization capability, making it a promising material for the fabrication of anisotropic scaffolds via melt extrusion AM for cardiac tissue engineering applications.

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