3D Precision Microfabrication Technology: From Tissue Engineering Scaffolds to Cardiovascular Stents

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Abstract

The loss or failure of an organ or tissue is one of the most devastating and costly problems in healthcare today. There is an increasing demand to find solutions for repairing injured and/or diseased tissues and organs. In an effort to meet this considerable challenge, 3D Biotek has developed 3D Precision Microfabrication Technology to fabricate porous structures of intricate shape and/or patterns with precisely controlled pore size and porosity. The application of this novel technology in biomedical fields is endless. Both degradable and non-degradable polymers, such as polycaprolactone (PCL), poly(lactide-co-glycolide) (PLGA), poly(DL-lactide) (PDLLA), polyglycolide (PGA) and polystyrene (PS), have been used to develop scaffolds for orthopedic and tissue engineering research, as well as for creating normal and diseased *in vitro* tissue models. Based on the 3D Precision Microfabrication Technology platform, 3D Biotek has recently developed a Rapid Stent Fabrication (RSF) System which can be used to fabricate bioabsorbable porous tubular structures for blood vessel regeneration and cardiovascular stent applications. Porous tubes and stents for cardiovascular applications have been successfully fabricated using biodegradable polymers such as PCL, PLGA and PGA. The world's first CAD-based RSF System has the capability to quickly and reproducibly fabricate bioabsorbable polymer stents directly from polymer pellets/powders. Moreover, this fabrication system makes very efficient and cost-effective use of expensive polymers, and can therefore accelerate the product development process and reduce the overall R&D cost. Ultimately, this RSF System introduces a new method for the fabrication of drug loaded bioabsorbable stents.

Materials and Methods

3D Precision Microfabrication Technology

PCL, PLGA, PDLLA, PGA, and PS scaffolds were engineered using 3D Precision Microfabrication Technology. Uniquely, fiber diameter is controlled by nozzle diameter and spacing between fiber is controlled by a motion control system. The struts of each layer are oriented 90º relative to the struts of the layer immediately below. Before use, scaffolds are plasma treated (PS only) and sterilized.

Rapid Stent Fabrication Technology

Using PCL, PLGA, and PGA, tubular structures were engineered using 3D Biotek's Rapid Stent Fabrication Technology which uses Precision Microfabrication Technology as its platform.

Results and Applications

3D Precision Microfabrication Technology

Biodegradable polymers such as PCL (Fig. 1A) and PLGA (Fig. 1B) can be precisely engineered into complicated, yet precise shapes and patterns.

Figure 1. Biodegradable Tissue Engineering Scaffolds for Orthopaedic and Tissue Engineering Applications

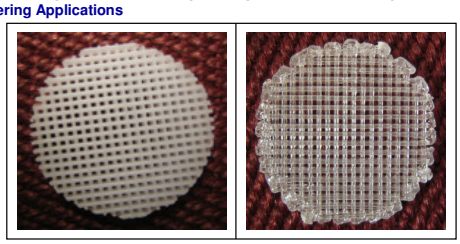
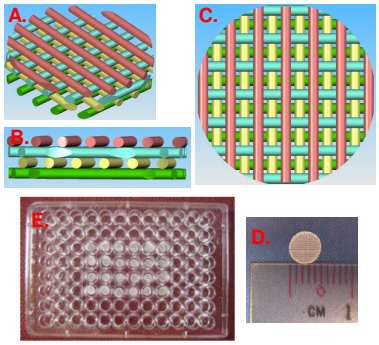


Figure 2A-C represents the four-layer structural design of 3D Biotek's 3D Insert™-PS scaffolds. Offset fibers allow for each of the PS scaffold's four distinct layers visible when viewing with an inverted light microscope.

An example of 3D Biotek's 96-well compatible PS scaffolds, 5 mm in diameter (D), with 150 µm fiber diameter and 200 µm pore size configuration (E).

Figure 2. Novel Polystyrene Scaffold for Creating an *In Vitro* tissue model



Rapid Stent Fabrication Technology

RSF Technology can be used to fabricate bioabsorbable porous tubular scaffolds from PCL, PLGA, and PGA polymers, which have extensive applications, including the cardiovascular field. Figure 3 shows an intricately engineered, tubular PCL scaffold. Also possible with this technology are biodegradable periphery vascular (ID 8 mm) (Fig. 4A-B) and balloon expandable coronary stents (ID 4 mm) (Fig. 4C)

Figure 3. Bioabsorbable Porous Tubular Scaffolds (PCL)

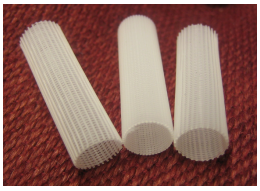
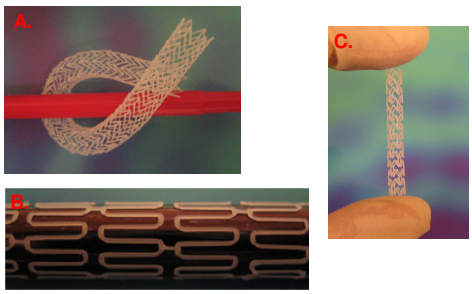


Figure 4. Bioabsorbable Scaffolds



Conclusion

Our results demonstrate 3D Precision Microfabrication and Rapid Stent Fabrication Technology introduce new methods for the precise and reproducible fabrication of intricately shaped/patterned structures. This technology has vast applications for regenerative medicine, specifically here to orthopaedic and cardiovascular fields. Furthermore, 3D Biotek believes that the use of these technology will reduce overall development costs and accelerate the labor-intensive development process.

Acknowledgements

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