4D Shape-Morphing Polymeric Biomaterials

Leonid Ionov*

* University of Bayreuth, Universitätsstr. 30, 95440 Bayreuth, Germany
e-mail: leonid.ionov@uni-bayreuth.de, web page: /www.ionovlab.uni-bayreuth.de

ABSTRACT

One of most powerful fabrication technique – 3D printing still has certain limitations, which substantially restrict its broader use. These disadvantages are inability to achieve sufficient resolution and high-density cell printing, difficulty of fabrication of multicomponent and hollow structures, difficulty of orienting of cells and limited oxygen diffusion. We advanced design of biomaterials by developing 4D biofabrication approach using special polymers, which are able to change their shape – shape-morphing polymers. In particular, we developed a number of approaches for design of biocompatible shape-morphing polymeric objects using solid polymers and hydrogels, which are able to change their shape in response to such "biocompatible" stimuli as temperature and presence of calcium ions. We developed approaches for deposition of cells on and inside of shape-morphing polymeric objects. We have also demonstrated application of 4D biofabrication approach for controlled encapsulation of cells, design of porous scaffolds with controlled porosity and pore orientation, complex 3D cell patterning as well as fabrication of hydrogel-cell hollow structures.

The approach was exemplified by gelatin-polycaprolactone (PCL) bilayers. Non-crosslinked gelatin was used as a sacrificial material, which prevents folding of the crosslinked gelatin-polycaprolactone bilayer at room temperature und allows its folding at elevated temperature. The approach has been used for encapsulation of neural stem cells. Very recently, we developed another approach for fabrication of shape-changing structures. The approach is compatible with 3D printing and allows fabrication of tubular cellular structures using shape-changing and is based on biopolymers with carboxylic groups such as alginate and hyaluronic acid. These polymers, when crosslinked, demonstrate reversible swelling properties in response to changes in Ca2+ concentration enabling shape-changing alginate and hyaluronic acid structures loaded with cells. The mouse bone marrow stromal cells survived photocrosslinking, changes in shape and remained vital for at least 7 days.

REFERENCES

Advanced Materials 2017 DOI: 10.1002/adma.201703443; Angewandte Chemie 2016, 55 (52), 16106–16109.; Advanced Functional Materials 2016, 26 (42), 7733–7739.; Advanced Materials 2015, 27 (33), 4865-4870.; Nano Letters 2015, 15 (3), 1786–1790.; Advanced Functional Materials 2014, 24(27), 4357–4363.; Biomacromolecules 2011, 12 (6), 2211–2215.