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Effect of process parameters on hardness of SLM-Mg material

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World-wide effort is made to develop metallic resorbable implants for osteosynthesis and vascular applications. The concept is to provide a biomaterial with initial mechanical stability supporting the tissue during its healing phase. However, after subsequent degradation of the implant material, no foreign body remains long-term nor has to be removed. Due to its biocompatibility and mechanical properties the material of choice is magnesium. Our research aims at exploring a route to produce Mg-implants by Selective Laser Melting. A variety of process parameters was applied to investigate the process window. There are several challenges to fabricate dense and stable structures, amongst others we mention: i) Process emissions that develop during the laser process under protective Argon atmosphere and ii) the choice of the applied laser energy and scanning speed to entirely melt the starting powder and fuse it into a dense material. A SLM Realizer 100 machine (MCP Realizer, Germany) was used to build 5 mm^3 cubes out of Mg powder (AZ91, SFM, Switzerland). The Vickers hardness of cubes built with different process parameters was investigated with a Zwick Roell ZHV 10 system (Ulm, Germany). The results showed that the prevention of the process emissions as well as the adaption of the laser parameters have a significant effect on mechanical properties of the created material.

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3-D Printed Bioreactors: Perspectives and Concepts

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Bioreactors are essential for the cultivation of complex cell and tissue constructs and for dynamic cell cultivation. Nowadays bioreactors are mostly complex systems of reusable glass vessels, roller pumps, heaters, sensors, etc., free and manually connected with plastic tubes and electric cables. This leads to large and expensive constructions, the danger of microbial contamination, and the need of high volume of culture medium due to large caliber and long running tracks. Therefore, with present bioreactors a parallelization and miniaturization, as it is established for microtiter plates and static cell-based assays, is almost impossible to realize. In the present study we have evaluated the possibility to realize miniaturized and disposable, and therefore highly parallelizable bioreactors using additive manufacturing processes (3-D printing). A variety of appropriate manufacturing technologies including Digital Light Processing (DLP), Fused Deposition Modeling (FDM), MultiJet Modeling (MJM), and Selective Laser Melting (SLM) were considered, as well as well-established and innovative biocompatible polymeric materials as matices. A special focus was set on the realization of small caliber and densely packed channels, optical windows for microscopic examination, wall heating systems, and power conducting structures. The present study showed that additive manufacturing processes offer revolutionary possibilities to realize highly integrated, miniaturized, single-use bioreactors with improved functionality. This leads to the perspective to perform highly parallelized multiparameter investigations on complex in vitro cell and tissue models, as it is already established for static cell culture models in microtiter plates.

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In situ photopolymerized composite hydrogels for implants: application to a nucleus pulposus replacement

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The nucleus pulposus (NP) is the core of the intervertebral disc (IVD). NP replacements have been subject to highly controversial discussions over the last forty years. Their utility seems to be eminent to treat herniated disc or degenerated disc disease (DDD). But, in practice not a single implant or tissue replacement was able to withstand the loads within an IVD. Hence, spinal-fusion remains the main treatment for DDD. The existing NP replacements suffer from extrusion and subsidence.
A composite hydrogel was designed by combining Poly-Ethylene-Glycol-Dimethacrylate (PEGDA) with Nano Fibril Cellulose (NFC) fibres. To inject the PEGDA-NFC hydrogel and activate it by light illumination in situ, a minimally invasive surgical device was developed. To validate the approach the NP of bovine IVDs was removed and hydrogel samples were placed within the degenerated IVD disc model. After surgery the IVDs were cyclically loaded in a bioreactor over more than 0.5 million cycles and the change of organ height was compared between healthy, degenerated, repaired and cyclically loaded states.
The developed hydrogel could be tuned according to native material properties and was able to reach similar material properties in terms of swelling pressure, extrusion and confined compression strength. It was successfully implanted and photopolymerized within the IVD model and was able to resist cyclic loading over 0.5 million cycles. The post-operative disc high increase was 33.4 % and was significant between degenerated/repaired state ($p < 0.0025$) and between degenerated and loaded state ($p < 0.025$). Histology of the samples showed a continuous interface between native tissue and implanted hydrogel. The minimally invasive implantation by in situ photopolymerization is a unique feature to control the surgery and provide optimal tissue integration. The restauration of disc height over 0.5 million loading cycles suggests that the orthopaedic implant could also be functional in humans.