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Abstract

Lithography-based 3D printing of multiscale scaffolds using zinc oxide tetrapods

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Zinc oxide (ZnO) has aroused great interest in recent years due to its multifunctional usability, particularly in the context of biomedical applications. A particular focus is on the use of tetrapodal ZnO micro- and nanoparticles, which have a unique 3D shape that is ideal for fabricating self-organized, highly porous micro-architected networks [1]. Due to their excellent degradability, t-ZnO networks can then serve as a sacrificial template for functionalization with low-dimensional nanomaterials such as graphene oxide (GO) or polymers like hydrogels [2]. Through etching the t-ZnO template so called aeromaterials can be obtained. Their open structure and tube-like arrangement transfer mere surface properties to volume properties with entirely new qualities emerging from this way of assembly.

Molding processes can quickly produce t-ZnO networks, but the resulting geometries are limited. The production of more complex structures, e.g., with undercuts or designed macroporosity, from pure t-ZnO has hardly been possible to date. These are vital, however, in applications like cell templates to grant cells and nutrients easy access to the networks. Developing a suitable additive manufacturing process for the fabrication of well-designed macroscopic structures with an inherent self-organized microstructure for biomedical or catalytic processes is, therefore highly desirable.

Here, we describe the development of a lithographic additive manufacturing process for processing highly filled t-ZnO slurries. Stable slurries could be developed by adapting the monomer composition, accompanied by rheological and sedimentation analyses, and the first scaffolds based on a gyroid design were manufactured with adapted printing parameters. Based on a thermogravimetric analysis, an appropriate thermal post-treatment protocol was established and final t-ZnO scaffolds with a self-organized microstructure were obtained. Scanning electron microscopy confirmed the highly porous microstructure of a t-ZnO network.

The scaffolds described here serve as a basis for further functionalization and show a promising approach for fabricating highly functionalized 3D-printed networks for biomedical applications.

Author's statement

Conflict of interest: Authors state no conflict of interest. Animal models: Not applicable. Informed consent has been obtained from all individuals included in this study. Ethical approval: Not applicable. Acknowledgments: We thank Michaela Kreienmeyer for her help as well as Samuel John and Hörsys for the access to their autoklave. Acknowledgments: Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - SFB 1270/1,2 – 299150580 and DFG research equipment funding – INST 264/186-1 FUGG

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