Investigation of Biocompatible Thiol/Yne Formulations for 3D Printing of Medical Scaffolds

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Abstract

In recent years UV-based 3D printing technologies such as stereolithography have become a growing field of research in biomedical engineering. The fabrication of drilling guides for dental implants or ear-shaped hearing aids is already considered as standard. More novel applications such as bone scaffolds are yet to be mastered. With the advance of this novel technique production cost and time are expected to drastically decrease.

For these applications, including bone screws and stents, a variety of materials, reaching from metals, ceramics to polymers can be considered. Polymers represent the most adaptable class of materials due to the great freedom of design in their molecular structure. Commenly used resins for lithographic 3D printing are multifunctional, commercial (meth-)acrylates, which exhibit a chain-growth mechanism. This results in a heterogeneous network structure with a high internal stress and a monomer conversion ranging from 60-90%. The remaining (meth-)acrylates, which are known to act as Michael acceptors can migrate and interact with physiological thiols and amines, e.g. proteins or DNA molecules.

Thiol-yne systems have been explored as biocompatible photoreactive resins. These polymers, which exhibit a step-growth mechanism, feature a delayed gelation point, resulting in a significantly lower internal stress and a higher overall conversion of about 99-100%.

In our work we present the direct modification of a commercially used bifunctional acrylate to obtain multifunctional alkynes which can be used for thiol/yne formulations. We report on the synthesis, the photochemical characterization, the mechanical properties, the biocompatibility and the 3D printing behavior (Figure 1). The increased monomer conversion, and the resulting improved biocompatibility make the proposed thiol/yne systems interesting candidates for photoreactive resins for 3D printable biocompatible applications.

Image

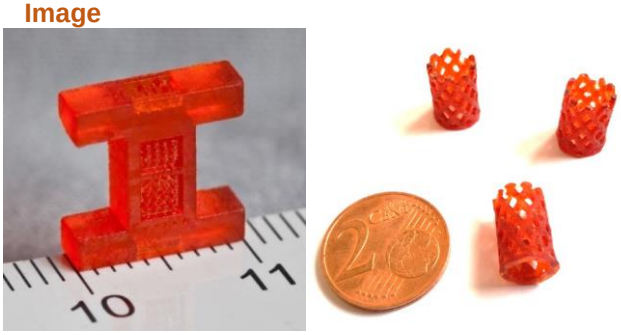


Figure 1: 3D printed test patterns out of a thiol/yne formulation; using Sudan II as a light absorber. (Scale on the left shown in cm)

Recent Publications

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3. LiX, SchwachaMG, ChaudryIH, ChoudhryMA (2008)Acutealcohol intoxication potentiates neutrophil-mediated intestinal tissue damage after burn injury. Shock 29:377.
4. M. Schuster, C. Turecek, G. Weigel, R. Saf, J. Stampfl, F. Varga und R. Liska, J. Polym. Sci. A Polym. Chem., 2009, 47, 7078-7089.
5. S. C. Ligon-Auer, M. Schwentenwein, C. Gorsche, J. Stampfl und R. Liska, Poly. Chem., 2016, 7, 257-286.
6. L. S. Andrews und J. J. Clary, J. Toxikol. Environ. Health, 1986, 19, 149-164.
7. A. Oesterreicher, J. Wiener, M. Roth, A. Moser, R. Gmeiner, M. Edler, G. Pinter und T. Griesser, Polym. Chem., 2016, 7, 5169-5180.
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Biography

Daniel Hennen studied chemistry at the university of Bonn (Germany) and achieved his master´s degree with the research of macromolecular transferred electron devices in the working group of Prof. Dr. S. Höger. Currently he is a PhD candidate at the Christian Doppler Laboratory for Functional and Polymer Based Ink-Jet Inks of the Montanuniversity of Leoben (Austria) in the working group of Prof. Dr. T. Griesser. He is working on the field of biocompatible photopolymers and investigates novel compounds for thiol/yne and thiol/ene formulations which are used for rapid prototyping. Additionally he works on the synthesis of novel water-soluble photoinitiators for UV cured water-based inkjet inks.

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Notes/Comments: