H-BOND STABILIZED SHAPE MEMORY POLYMERS: FROM 3D TO 4D PRINTING

Andrea Cosola[a], Marco Sangermano[a], Davide Terenziani[b], Riccardo Conti[c], Massimo Messori[b], Hansjörg Grützmacher[c] and Annalisa Chiappone[a]

[a]Department of Applied Science and Technology, Politecnico di Torino, 10129 Torino, Italy
[b]Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, 41125 Modena, Italy
[a]Department of Chemistry and Applied Biosciences, ETH Zürich, 8093 Zürich, Switzerland

In the last years, the use of smart materials capable of transforming with time under the application of an external stimulus, such as shape memory polymers (SMPs), allows to go further the static nature of the traditional 3D – printed objects, paving the way to the so-called four-dimensional (4D) printing [1].

In this work, we investigated the fabrication of SMPs by means of digital light processing (DLP) 3D – Printing. Differently from the traditional strategy which relies on using semi-crystalline polymers, we prepared SMPs stabilized by thermoreversibly associating hydrogen-bonds. In fact, the presence of reversible binding groups (RBGs) that constantly break and reform in dependence of the temperature allows to stabilize the programmed temporary shapes [2]. For this purpose, a solvent-free photopolymerizable system was used, consisting of monofunctional-methacrylates bearing groups that can reversibly associate into a non-covalent H-bonding network. A multiphotoactive bisacylphosphaneoxide derivative was synthetized and used as an all-in-one multifunctional photoinitiator (MFPI) and photocrosslinking agent, so that no additional cross-linkers are needed [3]. The thermomechanical analyses confirmed the versatility of such system, since DLP – printable materials having shape memory behavior at different temperature can be successfully prepared by simply adjusting the formulation compounding, exploiting the influence of the H-bonding network. Finally, a prototype of thermoresponsive airflow diverter has been fabricated to prove the integration of such SMPs in the development of smart 3D – printed devices.

[1] X. Kuang, D. J. Roach, J. Wu, C. M. Hamel, Z. Ding, T. Wang, M. L. Dunn, H. J. Qi, Adv. Funct. Mater. 2019, 29, 1805290.

[2] C. L. Lewis, E. M. Dell, J. Polym. Sci. Part B Polym. Phys. 2016, 54, 1340.

[3] A. Cosola, R. Conti, V. K. Rana, M. Sangermano, A. Chiappone, J. Levalois-Grützmacher, H. Grützmacher, Chem. Commun. 2020, 56, 4828.