Toward Sustainable 3D Printing: Developing High-Performance Photocurable Resins from Waste Chemical

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Digital Light Processing (DLP) is a lithography-based 3D printing technique in which a liquid photopolymer resin contained in a vat is cured layer-by-layer under UV light according to a 3D computer-aided design model to give 3D printed thermosets. DLP offers several advantages, including high resolution, rapid fabrication, and the ability to produce complex architectures.[1] Despite these advantages, there is still a gap that needs to be filled in, since the great majority of commercially available UV-curable resins are derived from non-renewable petroleum feedstocks, and the produced thermosets cannot be recycled or sustainably degraded at the end of their life. Consequently, these aspects, combined with the expected growth of the global 3D printing market[2], will increase environmental pollution and the dependence on petroleum. To address these environmental concerns, research is focusing on developing sustainable photopolymer resins which still exhibit inferior thermal and mechanical performances compared to their petroleum-based counterparts. To fill this gap, this work aims at developing more environmentally friendly resin formulations based on a novel cross-linker synthesized starting from glycerol, a byproduct of biodiesel production[3], creating thermosets with thermomechanical properties comparable or superior to commercially available petroleum-based resins, while using a waste material to obtain value-added products contributing to a more circular and sustainable materials economy. Moreover, the formulations will be produced according to a one-pot approach, in which the cross-linker is synthesized directly during the mixing of the formulation ingredients, simplifying the process and enhancing scalability. Initially, the work includes the determination of the thermomechanical properties of commercially available resins to determine the minimum performance standards to be achieved for 3D printed products, thus defining a benchmark. Subsequently, glycerol-based resins will be developed and characterized to understand how their final properties can be modulated by controlling both the reaction conditions of the cross-linker synthesis and the overall chemical composition of the formulation. Finally, the thermomechanical properties of the sustainable resins will be optimized, and key sustainability parameters will be determined to enable a quantitative comparison with commercial petroleum-based resins. Preliminary results from this work suggest that the developed formulations represent an interesting and profitable prospect for the future of the 3D printing market and the environment. In conclusion, this work aims at developing glycerol-based sustainable resins for 3D printing with competitive thermomechanical properties for a lower impact of this ever-expanding market on the environment.

Keywords: *3D printing, Digital Light Processing, sustainable UV-curable resins, waste valorisation*

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