Melt Electrowriting of Photo-Responsive Liquid Crystal Elastomer Actuators

María Fernández-Melero[1], Carlos Sánchez-Somolinos[1, 2]

[1] Instituto de Nanociencia y Materiales de Aragón (INMA), CSIC-Universidad de Zaragoza, Advanced Manufacturing Laboratory. Departamento de Física de la Materia Condensada, Zaragoza, 50009, Spain

[2] Centro de Investigación Biomédica en Red de Bioingeniería, Biomateriales y Nanomedicina, Instituto de Salud Carlos III, Zaragoza, 50018, Spain

Email of communicating author: mfernandezmelero@unizar.es

Melt electrowriting (MEW) is a high-resolution additive manufacturing technique that enables the digitally controlled deposition of ultrafine fibres. Recently, MEW has been combined with liquid crystal elastomers (LCEs) to develop thermo-responsive scaffolds in which the molecular alignment is defined by the printing path [1]. In this work, we report the MEW of photo-responsive LCEs by incorporating azobenzene units into the polymer network. The macromers were synthesized following a thiol-acrylate Michael addition reaction using an excess of acrylate groups, enabling subsequent photocrosslinking through free-radical polymerisation. By tuning the printing parameters, we fabricate square-lattice scaffolds with fibre diameters in the order of tens of micrometres and inter-fibre distances as low as 200 μm with different numbers of layers, as well as more complex patterns, reaching dimensions that are difficult to obtain using conventional direct-ink-writing methods.

The mechanical response of the printed fibres was characterised under both thermal and light stimulation. The fibres exhibit reversible thermomechanical deformation upon heating, and, under ultraviolet irradiation, reversible actuation is observed through two different mechanisms: a photothermal response driven by light-induced heating, reversed when irradiation ceases, and a photochemical response originating from trans–cis isomerisation of the azobenzene units [2], which can be reversed by green-light irradiation. Notably, despite the small fibre diameters, a light-intensity gradient is established across the fibre thickness upon irradiation, generating dissimilar photoinduced stresses that result in bending deformation [3]. This behaviour, well documented in LCE stripes [4], has not been previously reported in melt-electrowritten fibres.

These results show the potential of MEW for the fabrication of photo-responsive LCE structures and open new design possibilities for light-driven fibre-based actuators for soft robotics and biomedical applications.

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