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Correlation between rheological behaviour and printability of magneto-active elastomers

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Abstract

The development of reinforced materials has provided new insights into extrusion-based additive manufacturing (EB-AM) technologies, representing a step forward towards the new concept of 4D printing. This novel field permits not only to control structural characteristics but also to include additional functionalities that vary in space and/or time. Of all the EB-AM techniques, we focus on the potential of direct ink writing (DIW) for manufacturing particle-reinforced elastomers for soft robotics applications. In DIW, a pre-cured polymeric “ink” is extruded through a nozzle. To ensure both printability and shape fidelity, this ink should exhibit specific rheological behaviour and surface tension. In addition, good fusion between adjacent filaments is crucial to ensure that the components match the original computer-designed object, while also presenting good mechanical properties and additional functionality. In this work, we propose a hybrid experimental-computational methodology to understand the behaviour of the material after it leaves the nozzle and the mechanics that drive the coalescence between printed filaments. This combines experimental and computational tools. First, we carry out rheological and surface tension characterisation of different particle-reinforced inks, followed by filament fusion testing. In the latest, we record the coalescence process between adjacent filaments deposited in the same layer and in different layers, in

order to understand the roles of viscosity and surface tension. Finally, we use a phase-field model to simulate filament fusion. This new methodology helps us understand the DIW process, providing new insights into the ideal properties of particle-reinforced ink to optimise printability, dimensional accuracy, and component performance.
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