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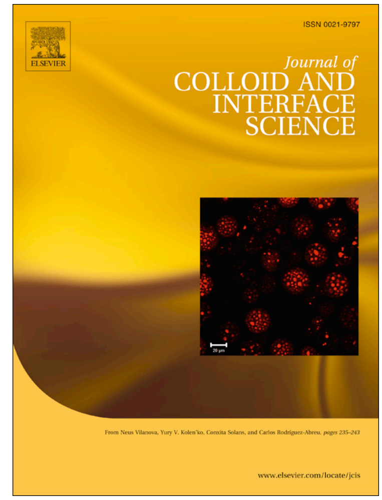

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In situ characterization of low-viscosity direct ink writing: stability, wetting, and rotational flows

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Abstract

Hypothesis

Direct ink writing (DIW) of composites can be coupled with magnetic, electric, or acoustic fields to control spatial variations of microstructure that enhance performance. The use of such external fields often requires inks with lower viscosities than conventional DIW, which presents new challenges with regards to maintaining the stability of printed lines and targeted microstructures. In-situ monitoring of the print bead, combined with slot-die models, can be used to predict printing modality and guide printing protocols for low viscosity inks.

Experiments

Using videos of the nozzle-substrate gap, we systematically study how ink composition, stand-off distance, and nozzle and substrate surface coatings influence the printing process. We establish in-situ digital image analysis techniques to evaluate filament stability, nozzle wetting, and rotational flows in low viscosity composite inks.

Findings

Variations in the fluid-substrate contact line position and angle can be used to evaluate stability on-the-fly, and lubrication theory can be used to predict filament-to-droplet transitions. To limit nozzle wetting and disruption of microstructures established in the nozzle, it is necessary to use

Abbreviations: DIW, direct ink writing; DMAEM, 2-(Dimethylaminoethylmethacrylate) (photoinitiator); FDTS, 2H,2H-perfluorodecyltrichlorosilane (nozzle coating); TEGDMA, triethylene glycol dimethacrylate (ink diluent); UDMA, diurethane dimethacrylate (ink base).

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