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NanoBiomaterials for 3D Bioprinting

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Abstract

3D bioprinting, a newly emerged branch of additive manufacturing, uses biomaterials and cells as "bioink" to print 3D tissue-like structures. The past few years saw a rapid rise in research on bioink materials, printing tools and methods. However, significant technological hurdles remain. Here, we report a series of studies on a hybrid bioink system incorporating a nanomaterial, cellulose nanocrystal (CNC), and polymers for the high-resolution and high-speed printing of 3D tissue constructs via microextrusion. CNC is a type of rod-shaped naturally occurring nanoparticles with proven biocompatibility. Our results show that CNC-polymer hybrid bioinks possess promising rheological and mechanical characteristics. In particular, their excellent shear-thinning property ensures facile extrusion through a small nozzle, high print fidelity, and protection of encapsulated cells from mechanical stress-induced cell damage. Model structures with well-defined biomimetic geometries were printed, e.g. bi-cellular liver lobule-mimicking constructs and layered colorectal tumor models. Cell viability, function, cell-cell interactions, and cell-extracellular matrix (ECM) interactions in the printed 3D structures were studied. Our studies offer a promising route to greatly enhance bioink formulations for printing complex architectures with multiple ECM components and cell types in sufficient resolution to recapitulate biological functions.