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3D printable nanocellulose-pectin ink formulations

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The freedom in design and customization of 3D scaffolds to enact specific physiological responses is the holy grail of materials fabrication. Although various biopolymers have shown biological properties, few are the ones that fulfil the considerable requirements for suitable ink formulations and sequential production of 3D scaffolds. Here, we present and asses several ink formulations for 3D printing exploiting the fast crosslinking potential of pectin and the remarkable shear thinning properties of TEMPO-oxidized nanocellulose, that is known to induce the desired viscoelastic behaviour required for direct ink writing. Pectin is a water-soluble polymer with a fairly good biodegradability which can be exploited in various application fields. Low methoxylated pectin (LM-pectin) is physiologically subjected to calcium-induced gelation and it has been recently considered for drug delivery and as a biomaterial for tissue regeneration. The composition of the inks was optimized through rheological and injectability tests prior the 3D printing experiments. The inks printability was evaluated considering various printing parameters and shape fidelity to successfully 3D print under ambient conditions a series of pectin-nanocellulose formulations. The printed patterns were further subjected to calcium-induced gelation to develop the crosslinked scaffolds. The resultant structures were characterized to investigate the influence of pectin/nanocellulose mass ratio on the water affinity, mechanical and morphological features. The structural integrity of the printed scaffolds and their mechanical strength are directly reliant on the pectin amount. This study clearly demonstrates the potential use of nanocellulose to improve the printing performance of pectin enabling the fabrication of 3D constructs.

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