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Evaluation of rheological properties and shape fidelity of PCL/HA inks for 3D printing of osteochondral tissue scaffolds

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Abstract

Objectives: The objective of this study is to investigate the effect of solvents and rheological properties of PCL/Hydroxyapatite ink on the shape fidelity of the 3D printed scaffolds for bone tissue engineering. Methods: A series of inks were made consisting of 50% (w/v) of polycaprolactone (PCL) filled with 0%, 3.5% and 12.5% (w/V) of hydroxyapatite (HA) in dichloromethane (DCM) and chloroform (CHF). Steady and oscillatory shear rheological tests were performed on a rheometer (Discovery HR-3). Solvent-cast direct ink writing was performed with a custom-made 3D printer for the fabrication of PCL/HA scaffold structures with 2-8 layers. Optical microscope and scanning electron microscopy (SEM) were used to assess the shape fidelity. Results: Shape fidelity of the inks was quantitively assessed on the 3D printed scaffold structures allowing subjective comparisons. The addition of HA particles increased zero-shear viscosity by up to 900%. For oscillatory tests, plateau of storage modulus was observed in the low-frequency region which is attributed to good dispersion of the HA particles inside the matrix that leads to the formation of filler networks, resulting in pseudo-solid behavior and shape fidelity improvement. As the HA concentration increases, the plateau becomes more pronounced and the shape fidelity increases. With the same concentration, all DCM inks also show higher viscosity (from 10% to 200%) and better shape fidelity than CHF inks. As DCM has a lower boiling point (39.6 °C) than CHF (61.2°C), DCM evaporates quicker reducing the fusion and diffusion of deposited ink filaments before solidification which is observed in SEM images. Conclusions: This study reveals insights into using rheological characterizations as a tool for evaluation of shape fidelity of solvent-based DIW inks and also provides fundamental information on the influence of different solvents on the fidelity of 3D printed scaffolds.

Declaration of Interest

(b) declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported:I declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research project.