EVALUATION OF BIOINK PRINTABILITY WITH QUANTITATIVE METHODS TO AID MATERIAL DEVELOPMENT

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During extrusion-based bioprinting, the deposited bioink filaments are subjected to deformations, such as collapse of overhanging filaments and fusion between adjacent filaments, which compromise shape fidelity of printed constructs. The degree of deformation of printed filaments could be used to quantitatively assess the printability of newly developed bioinks. This approach would be an alternative to current assessment through qualitative visual inspection after printing, which have been hampering any comparison between different bioinks. For this reason, we propose two quantitative printability tests based on the mentioned filament deformations: filament collapse of overhanging structures (Fig 1a) and filament fusion on parallel filaments (Fig 1b). Both printability tests were applied on two printable hydrogel platforms: poloxamer 407 and poly(ethylene glycol) blends (poloxamer/PEG), displaying a range of yield stress values. We also propose theoretical models for each test to predict printability from bioink yield stress. The results on poloxamer/PEG hydrogels show that as the yield stress decreases, the filament collapse is greater, decreasing the ability to maintain the shape of suspended filaments. Similarly, filament fusion occurs at bigger filament distances, decreasing resolution on the x-y plane. These results confirm that printability is largely dependent on yield stress. Our bioink printability testing is straightforward, assessible with any extrusion-based bioprinting system. The proposed method provides a quantitative evaluation based on physical deformation of printed filaments, potentially reducing long experimental trial-and-error printing with newly developed bioinks and allowing reproducible comparisons between different inks.

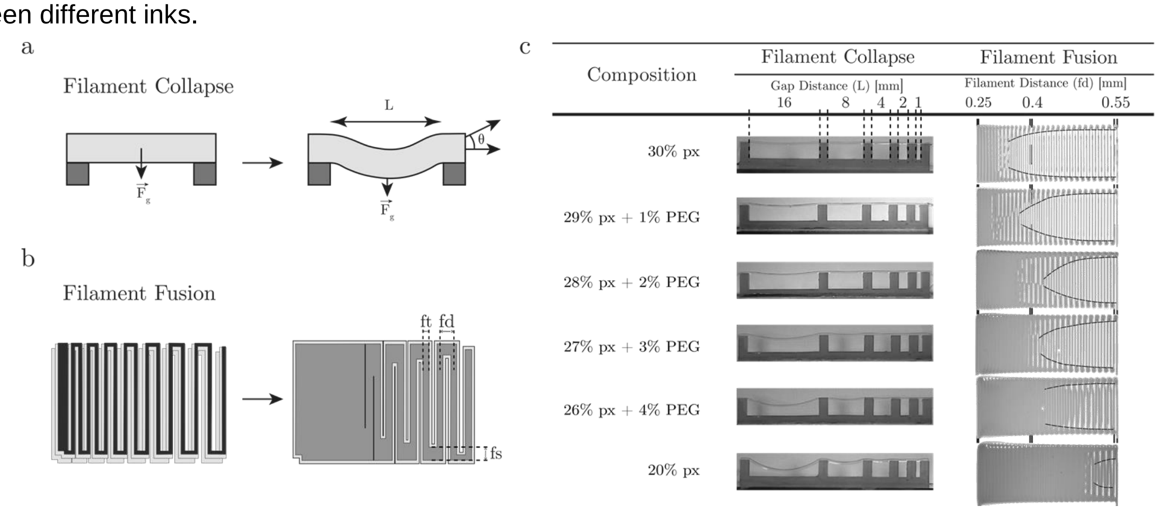

Figure 1 – Proposed printability tests. (a) Filament collapse was assessed by extruding a filament over gaps, and measuring angle of filament deflection with the horizontal (θ) for each gap distance (L). (b) Filament Fusion was assessed by printing three layers of parallel filaments with increasing filament distance (fd) between them. The ratio between the fused segment length (fs) and filament thickness (ft) was measured for each fd on the 3rd layer, printed with a different color. (c) Both tests were applied to poloxamer 407 gels. As the poloxamer is slowly replaced by poly(ethylene glycol) (left column), the viscosity and yield stress decreases, increasing filament sagging (middle column) and causing filament fusion at larger values of fd (right column).