BIOPRINTING OF COLLAGEN HYDROGELS IN A SUPPORTED GEL ENVIRONMENT

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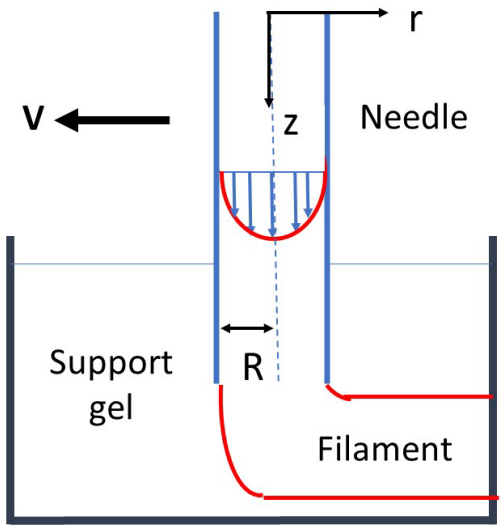
ABSTRACT

The challenge of 3D printing soft hydrogels such as live cell-embedded collagens in tissue engineering is to build complex structures while keeping overhanging features intact. Those requirements can be met by extruding "weak" printable hydrogels directly into the bath of a supporting gel. The supporting gel prevents the collapse or deformation of the printed object under its weight. Once the printing is completed, the object is cured, removed from the support bath, and rinsed off. This sacrificial supporting gel has to be removed easily after 3D printing. Supporting baths, based on crosslinked polyacrylic copolymer microgels, granular gels, silica nanoparticle suspensions, nano clay suspensions, hydrophilic poly(ethylene oxide) (PEO) (PluronicTM) are reviewed. The design of an appropriate supporting hydrogel bath poses several challenges. The supporting gel has to behave like Bingham plastic, not yielding until a threshold shear force is reached. In the meantime, its yield stress, τ_y has to be low enough to accommodate nozzle movement. Besides supporting the deposited printing gel, the support bath must exhibit a high plateau shear elastic modulus, G ′. In addition, those viscoelastic properties have been thermo-reversible. Our group has prepared and printed live cell-laden collagens in gelatin support baths for engineered nasal cartilage applications, which can potentially replace and reduce donor-site morbidities associated with native cartilage grafts taken from other anatomical sites for reconstructive nasal surgeries. In those studies, complex objects are printed in support gels with delicate structures.

FREEFORM PRINTING MODEL

In a typical freeform printing in a gel process, a filament drop is extruded from the dispensing needle with a release speed of V and dragged to a horizontal distance equal to the step distance with a path speed of v_o. This step-by-step horizontal movement of filament extrudate in the support gel bath can be modeled as shown in Figure 1.



Fgure 1: Filament depostion in a gel bath