Engineering alginate as bioink for bioprinting

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Statement of Purpose: 3D bioprinting provides a rapid and robust approach to fabricating functional tissues in vitro. To facilitate tissue formation, alginates have been extensively used as bioink to provide a matrix to direct a specific specific 3-D cell growth, because it can robustly form cell-compatible hydrogels in physiological conditions. In addition, they can be modified for a variety of tissue engineering applications, including bone, vascular and adipose tissue engineering. However, native alginate is a bioinert material with limited biodegradation. Also, little previous research has systematically investigated the effects of the physical properties of alginate solutions on printability.

In this study, a library of 30 different alginate solutions with varied oxidation percentages and concentrations was prepared to In this study, a library of 30 different alginate solutions with variety oxidation percentages and concentrations was prepared to In this study, a library of 30 different alginate solutions with varied oxidation percentages and concentrations was prepared to The research reported here will accelerate the development of alginate-based bioink for tissue-specific tissue engineering applications.

Methods: Materials and Cells: Oxidized alginate was conjugated with/without 1% RGD and made into 30 aqueous solutions (5 oxidation percentages* 6 concentration percentages). Human adipose-derived stem cell (hADSCs) was used as cell model. Two material properties, viscosity and density, were tested as the reference to characterize the printability. The printing process was achieved on the Palmetto Printer, a custom-made, piston-driven deposition system. The droplet volume was 230 nL. Dispense speed was 10 μL/Sec. The alginate solution was printed on the calcium-containing gelatin substrate.

Results: A collection of 30 different alginate hydrogels with varied oxidation percentages and concentrations was prepared to develop a bioink platform that can be applied to a multitude of tissue engineering application.

Two key material properties (i.e. viscosity and density) of alginate solutions were systematically investigated to identify a suitable range of material properties of alginates to be applied to bioprinting. The alginate solutions whose densities are above 1.05g/cm^{-3} can maintain homogenous cell suspension within 3 hours printing process. The alginate solutions whose viscosities are among ~400 mm^2/s and ~3000 mm^2/s can offer relatively higher printing resolution as well as viability for cells after printing.

Four alginate solutions with varied biodegradability were printed with hADSCs into lattice-structured, cell-laden hydrogels with high accuracy. Notably, these alginate-based bioinks were shown to be capable of modulating proliferation and spreading of hADSCs without affecting the structure integrity of the lattice structures (except the highly degradable one) after 8 days in culture.

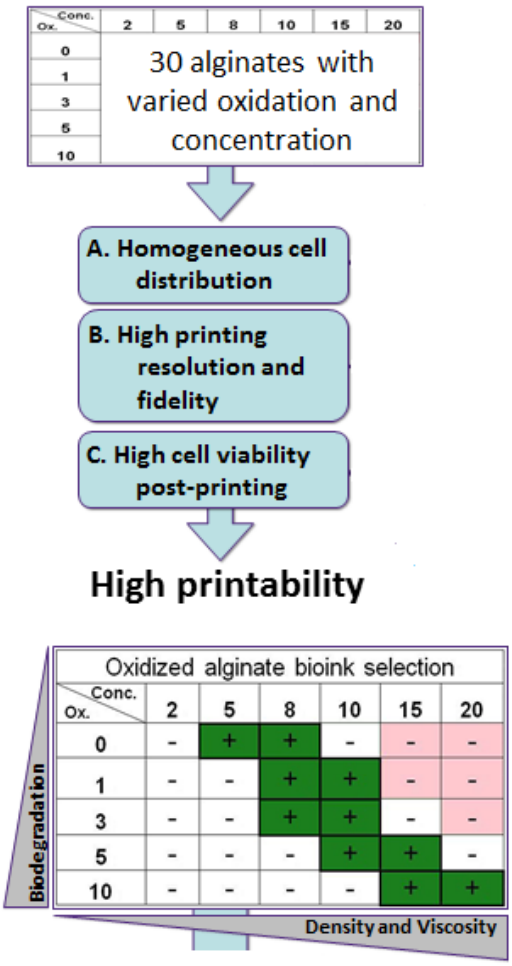

Figure 1. Schematic representation of biodegradable oxidized alginate as bioink for printing

Conclusions: An ideal printable range for using oxidized alginate as a bioink platform was established based on the material properties of alginate (i.e., viscosity and density), satisfying the high printability criteria: homogeneous cell distribution during operation, high printing resolution and fidelity and high cell viability post-printing

The observed functional relationship between the material properties (i.e., viscosity and density) of alginate and its printability allows for an enhanced progression in alginate bioink development for liquid-dispensing printing.

References: [**1**] Bouhadir KH, *et al.* Biotechnol Prog . 2001;17:945–950;

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