Effects of Photoinitiators on Cell Viability, Physical Properties, and Microstructure in 3D Bioprinting

Jazzmin Casillas, Heqi Xu, Dr. Changxue Xu
Texas Tech University, Lubbock, TX

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• Introduction and Background
• Materials and Methods
• Results
• Conclusions
Typical Bioprinting Techniques

- Inkjet-based Bioprinting
- Microextrusion Bioprinting
- Laser-assisted Bioprinting

[Foyt2018]
Typical Bioprinting Techniques

Stereolithography-based Bioprinting

Mechanism:
1. Divide 3D model into several 2D patterns
2. 2D pattern controlled by Digital micro-mirror device (DMD), projected onto the bioink (GelMA, photoinitiator, and living cells), and crosslinked upon UV irradiation
3. Z-stage moved down one layer thickness until completion of the full structure

Advantages:
• High resolution
• High deposition accuracy
• High fabrication rate
• High cell viability
A prevascularized tissue fabricated with digital light processing (DLP)-based 3D bioprinting (Zhu2018) with 85% cell viability after 7-day incubation (Bioink: 2.5% (w/v) GelMA, 1% (w/v) hyaluronic acid (HA), 0.15% (w/v) LAP and human umbilical vein endothelial cells (HUVECs) and 10T1/2s cells). The swelling ratio and the pore size of the hydrogel increases significantly within the first 24 hour incubation time.

A 3D Y-shaped tubular construct (Wadnar2019) with a post-printing cell viability of 75%. (Bioink: 5% (w/v) GelMA, 0.5% (w/v) Irgacure 2959, and NIH 3T3 fibroblasts)
Objectives

• To systematically study the effects of photoinitiator and printing time on cell viability during printing and the effect of photoinitiator and incubation time on cell viability after printing.

• To investigate the photoinitiator effect on the physical properties: swelling ratio and degradation rate.

• To characterize the photoinitiator effect on the microstructure (pore size) of the hydrogel.
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Experimental Setup

Key elements:
1. UV source
2. Digital micromirror device (DMD)
3. Lenses group
4. Bioink container
5. Motorized z-stage and platform
Bioink:

- 5% (w/v) GelMA
- Photoinitiator (Irgacure 2959 or LAP) concentration: 0.3 – 0.9% (w/v) with an interval of 0.2% (w/v)
- Cell concentration: $1 \times 10^6$ cells/mL

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<th>Photoinitiator concentration (%)</th>
<th>Incubation time (hour)</th>
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Representative cell viability images during 3D bioprinting

0.5% Irgacure 2959 at 30-minute

0.7% Irgacure 2959 at 30-minute

0.9% Irgacure 2959 at 30-minute

0.5% LAP at 0-minute

0.5% LAP at 30-minute

0.5% LAP at 60-minute
Effect of photoinitiator on cell viability during printing

- For lower concentrations, both photoinitiators are suitable for 3D bioprinting
- For higher concentrations, only LAP are suitable for short-time 3D bioprinting

Irgacure 2959

LAP
Photoinitiator effect on cell viability during printing

- The cell viability decreases with printing time and photoinitiator concentration.
- At the same concentration, the cell viability using LAP is higher.
Effect of photoinitiator on cell viability after printing

- Both types of photoinitiators have negligible effects on post-printing cell viability
Effect of photoinitiator on the physical properties

- Samples with Irgacure 2959: greater swelling ratio and faster degradation rate
Effect of photoinitiator on microstructure of hydrogel

- Samples cured with Irgacure 2959: slightly larger average pore size
Fabrication of a 3D vascular-like construct

- Most cells survive with a post-printing cell viability of 80%
- The actual measured dimensions show good shape fidelity
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Conclusions

• The cell viability during 3D bioprinting generally decreases with the increase of the photoinitiator concentration and printing time for both Irgacure 2959 and LAP;

• the photoinitiators Irgacure 2959 and LAP have negligible effects on the cell viability after 3D bioprinting; and

• GelMA samples cured with Irgacure 2959 have slightly larger pore size, faster degradation rate, and greater swelling ratio after 3D bioprinting compared to those cured with LAP.
Acknowledgment

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Thank You!

QUESTIONS

ANSWERS