Review & analysis of Gelatin Methacryloyl (GelMA) for tissue bioprinting

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Agenda

- Introduction
- Synthesis
- Bioprinting
- Commercial Landscape
- Applications
- Future

Introduction

What is GelMA?

GelMA

- Is denoted by various names: Gelatin Methacrylate, Methacrylated Gelatin, Methacrylamide modified Gelatin, or Gelatin Methacrylamide
- Derived from collagen
- Retains all the adherent abilities of collagen, while discarding the antigenicity
- It is a type of a HYDROGEL

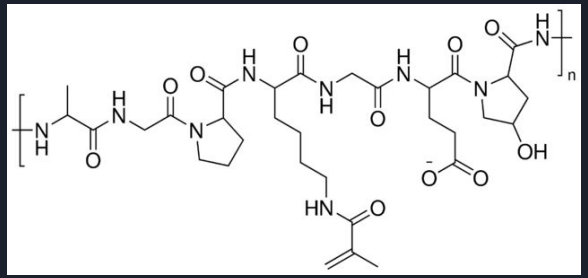

Figure 1: Chemical structure of GelMA,
Source:https://www.sigmaaldrich.com/catalog/substance/gelatinmethacrylo

Introduction

What is GelMA?

What are hydrogels?

Hydrogels

- 3D, Hydrophilic, and polymeric networks
- High water content, porosity and soft consistency emulating native tissue
- Tunable solubility characteristics

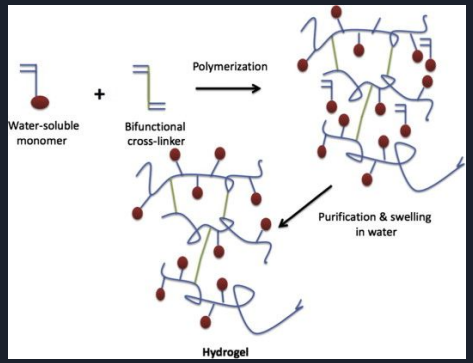

Figure 2: Generic hydrogel
Source: https://doi.org/10.1016/j.eurpolymj.2014.11.024

Introduction

What is GelMA?

What are hydrogels?

What is a bioink?

BioInk

- Analogous to ink in commercially used printers
- Contains living cells and biomaterials that mimic the ECM
- Supports cell adhesion, proliferation and differentiation after printing

Ideal conditions:

1. Must be printed at physiological temperature
2. Should have mild cross-linking or gelation conditions
3. Components should be non-toxic
4. Can be modified after printing

Commercially available Bioinks

Agarose	Graphene
Alginate	Hyaluronic Acid
Chitosan	Fibrin or Fibrinogen
Collagen	Hydroxyapatite
Decellularized ECM	PCL/PLA/PLGA
Gelatin	Pluronic

Source: Sigma-Aldrich

Synthesis of GelMA

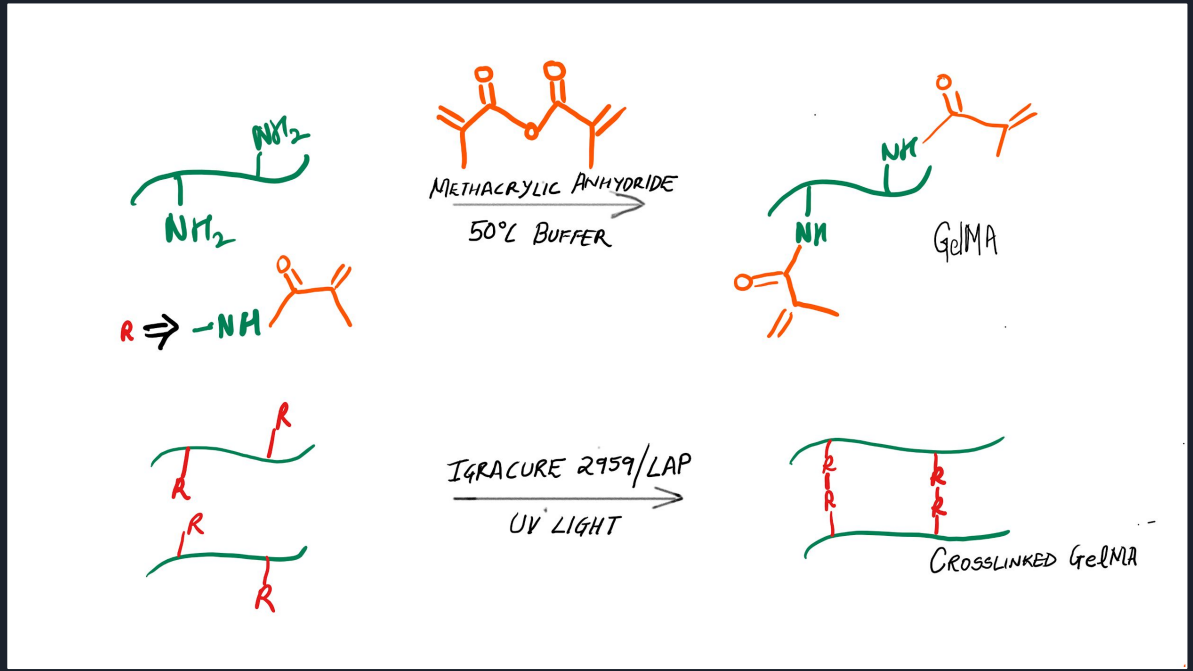

Figure 3: General Procedure to produce GelMA

Bioprinting Parameters

- Viscosity and Temperature

  Thermally unstable material → Displays an increment in viscosity when exposed to room temperature

- Crosslinking

  Methacrylic anhydride (MA) → Crosslinking with the assistance of a photoinitiator and exposure to light

Physical and Material Properties

- Swelling Ratio

$$\text{Mass Swelling Ratio} = \frac{\text{Swollen weight of the sample}}{\text{Dry weight of the sample}}$$

- Degradation Rate

$$D\% = \frac{W_0 - W_t}{W_0} \times 100\%$$

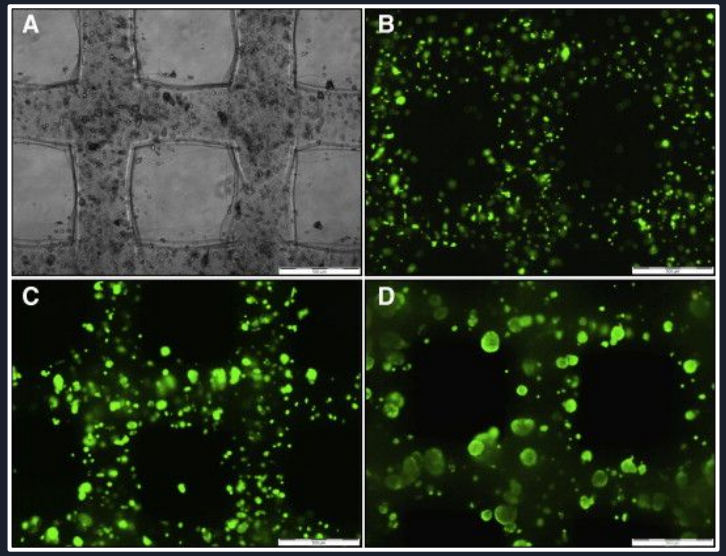

Figure 4: Cell Viability

Commercial Landscape

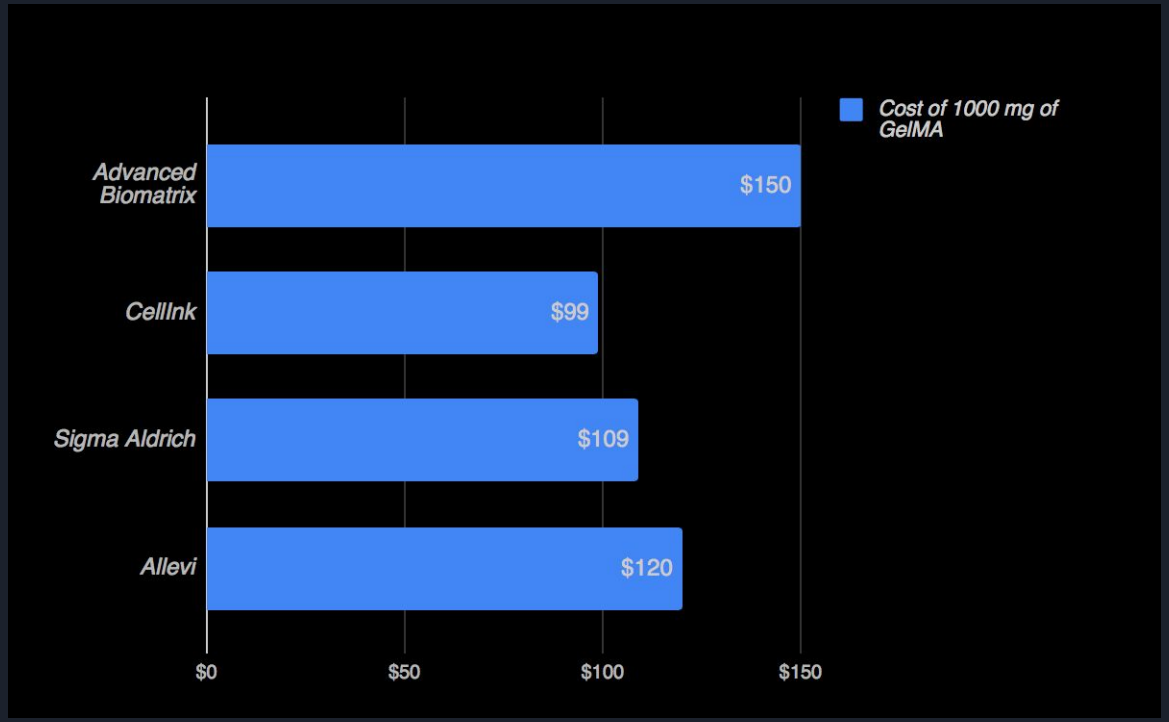

Figure 5: Benchmarking of GelMA

Applications

- BIOCOMPATIBILE
- BIODEGRADABLE
- NON-CYTOTOXIC
- NON-IMMUNOGENIC
- HIGH CELL-VIABILITY

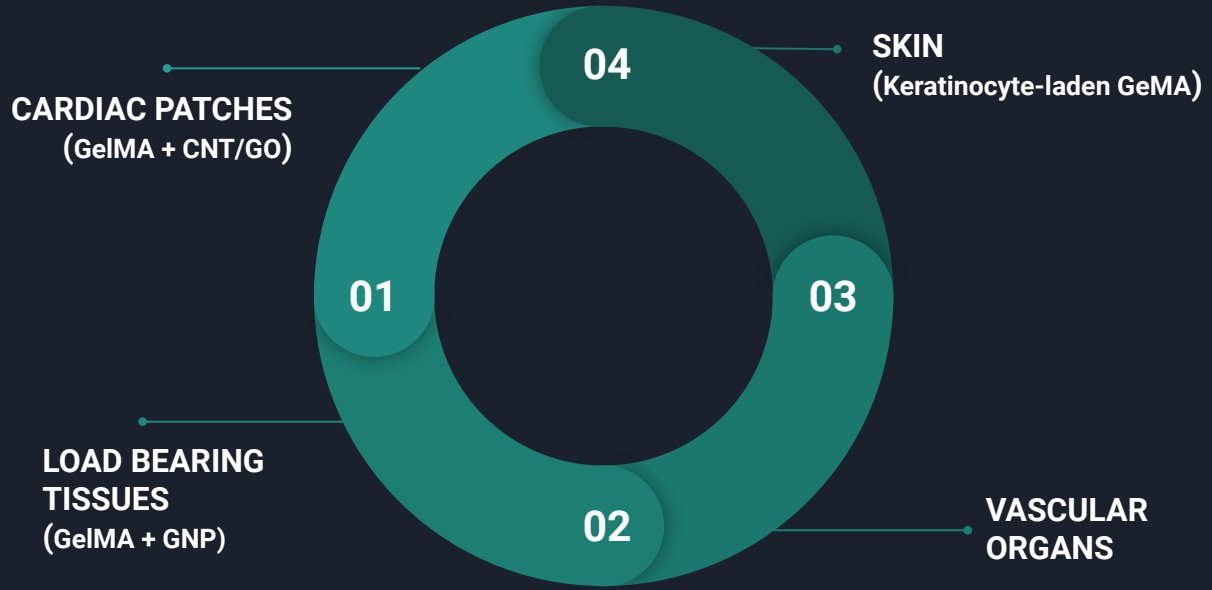

Figure 6: Applications of GelMA

Applications

- Research by Aubin et al.
- Cells could align, proliferate, and elongate
- Property essential to grow cardiac, muscle and vascular tissues

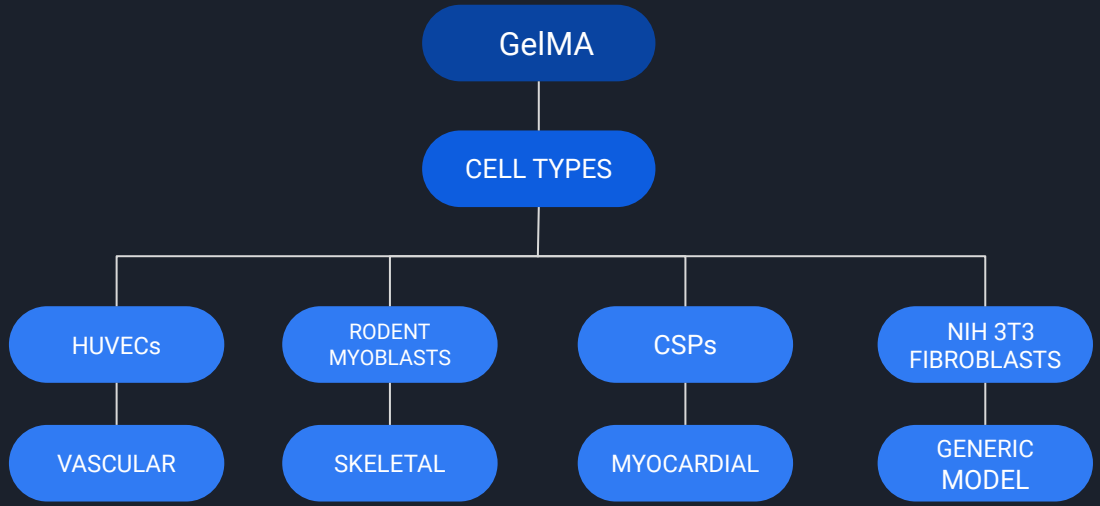

Figure 7: GleMA applications
Source: Aubin et al: Directed 3D cell alignment and elongation in microengineered hydrogels

Future

- New curing method to crosslink GelMA using visible light (DL)
- Opens up possibility for applications in regenerative dentistry
- Cycle time reduction, process cost reduction as curing is faster

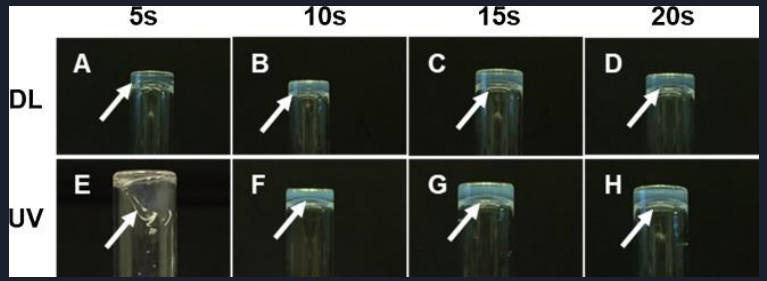

Figure 8: Comparison of Visible Light to UV as a source of polymerization

Source: Photopolymerization of cell-laden gelatin methacryloyl hydrogels using a dental curing light for regenerative dentist
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Thank you!