SMART MCs

GelMA Material Characterisation

Contact Us:

www.SmartMCs.com.au

Linkedin.com/company/Smart-MCs

info@smartmcs.com.au

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Smart MCs GelMA

Product Overview

GelMA (Gelatin Methacryloyl) is a versatile hydrogel commonly used in biomedical applications such as 3D bioprinting, tissue engineering, and cell culture. It is derived from gelatin, which is modified with methacryloyl groups to allow UV crosslinking. This modification makes GelMA adaptable for creating biocompatible scaffolds with customisble stiffness.

- Compressive Modulus: GelMA can be customized for both rigid and flexible scaffolds based on the amino substitution degree (GelMA-30, GelMA-60, GelMA-90).
- High Cell Viability: Supports cell types like stem cells, endothelial cells, and hepatocytes, with over 90% cell survival.
- Ideal for 3D Printing: Supports both extrusion-based and DLP bioprinting methods.

1. General Information

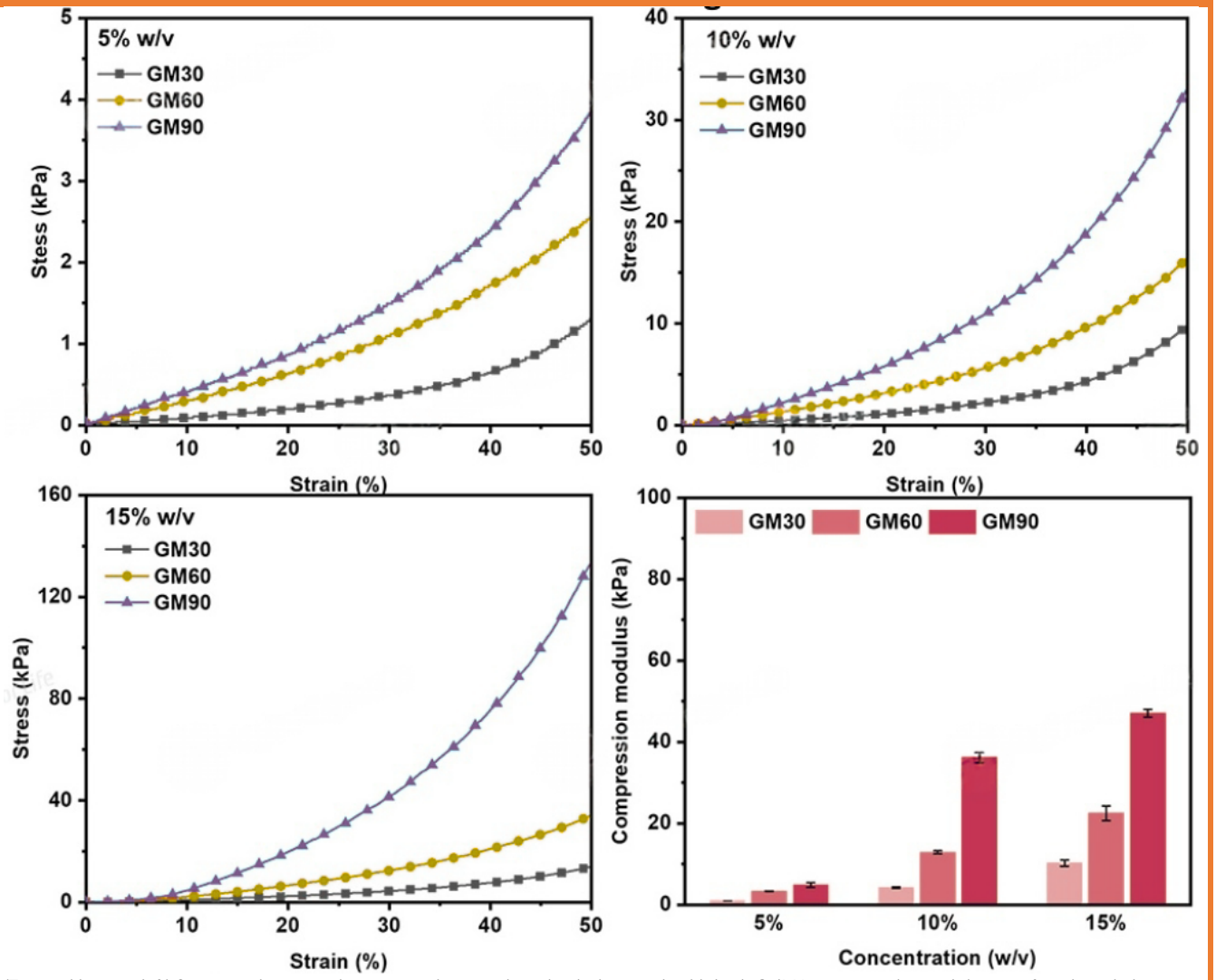
Model	Degree of Methacrylation	Molecular Weight	Turbidity	Appearance	
GM-30	30 ± 5%	100–200 kDa High	⩽ 20 NTU	White, sponge-like	1 g/vial (includes 0.05 g LAP photoinitiator)
GM-60	60 ± 5%				5 g/vial (includes 0.05 g LAP photoinitiator)
GM-90	90 ± 5%				10 g/vial (includes 0.05 g LAP photoinitiator)

2. Compressive Modulus Comparison

Mechanical performance of GM30, GM60, and GM90 across standard concentrations:

Concentration (%)	GelMA-30	GelMA-60	GelMA-90
5%	0.92 ± 0.001 kPa	3.34 ± 0.087 kPa	4.88 ± 0.622 kPa
10%	4.21 ± 0.179 kPa	12.88 ± 0.389 kPa	36.17 ± 1.250 kPa
15%	10.27 ± 0.774 kPa	22.48 ± 1.777 kPa	47.06 ± 0.974 kPa
Higher GM and concentration = greater stiffness and structural integrity.			

Figure 1: Mechanical Properties of GelMA Hydrogels Stress-Strain Behavior and Compression Modulus of GM30, GM60, and GM90 at 5%, 10%, and 15% (w/v), cured with a 405 nm light source for 30 seconds.



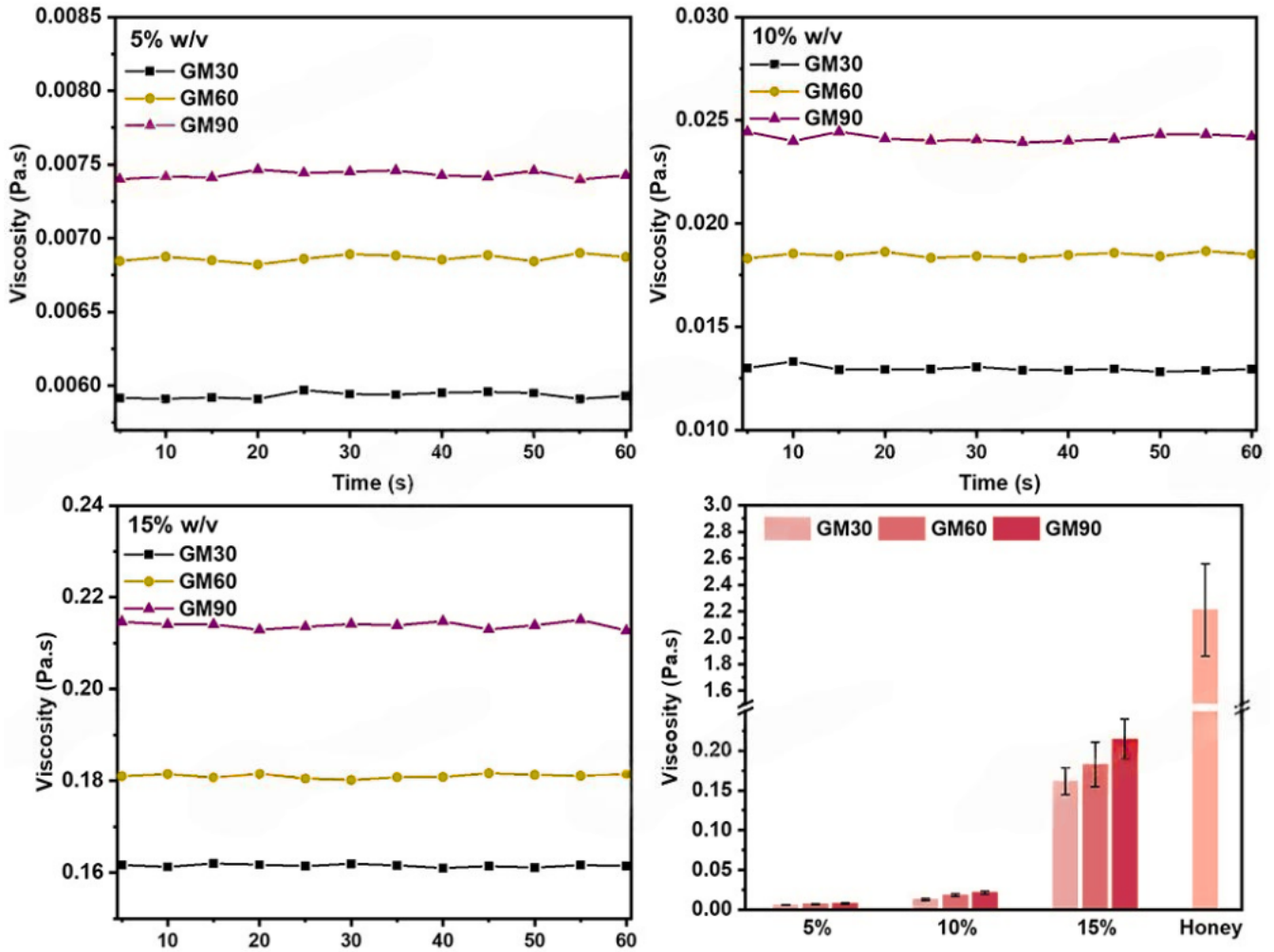
(Top and bottom left) Stress-strain curves demonstrate increased mechanical strength with both GelMA concentration and degree of methacrylation. (Bottom right) Compression modulus values range from ~2 kPa (5% GM30) to ~90 kPa (15% GM90), showing tunable stiffness across formulations.

3. Viscosity Comparison at 37°C

Viscosity directly affects printability. All GelMA types remain easily extrudable up to 15%, especially when maintained at 37 °C. Higher methacrylation and concentration increase viscosity, improving structural retention in printed constructs.

Concentration (%)	GelMA-30	GelMA-60	GelMA-90
5%	0.0059 ± 0.0004 Pa.s	0.0069 ± 0.006 Pa.s	0.0079 ± 0.005 Pa.s
10%	0.013 ± 0.003 Pa.s	0.018 ± 0.004 Pa.s	0.021 ± 0.06 Pa.s
15%	0.162 ± 0.03 Pa.s	0.183 ± 0.06 Pa.s	0.215 ± 0.05 Pa.s

Figure 2: Viscosity Profile of GM30, GM60, and GM90.



(Top and bottom left) Viscosity remains stable over 60 seconds and increases with both GelMA concentration (5%, 10%, 15% w/v) and degree of methacrylation (GM30, GM60, GM90).

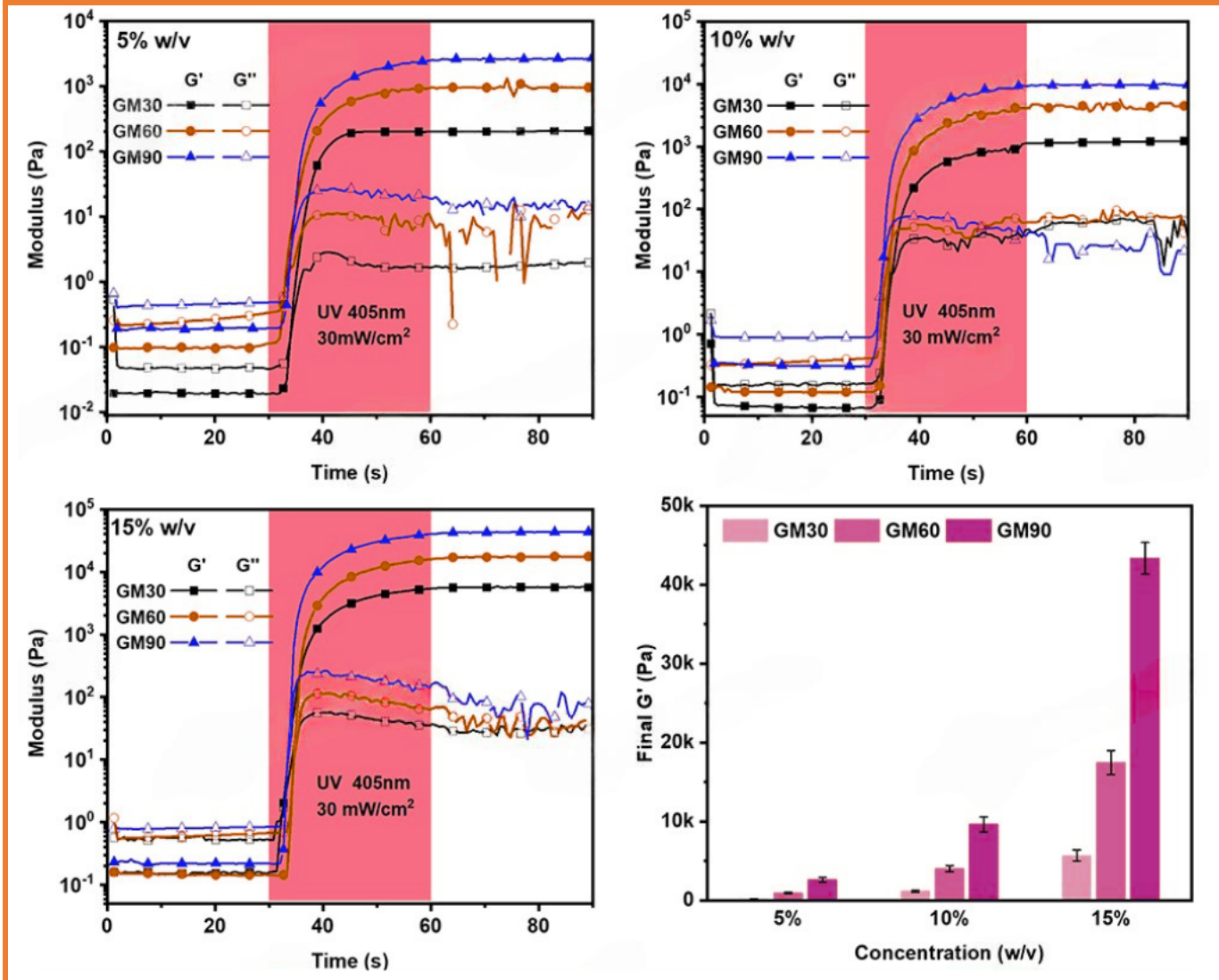
(Bottom right) At 5% w/v, viscosity ranges from 0.0059 Pa·s (GM30) to 0.0074 Pa·s (GM90); at 10% w/v, from 0.0125 to 0.0252 Pa·s; and at 15% w/v, from 0.1562 0.2171 Pa·s. Honey shows a viscosity of 2.61 Pa·s under the same conditions.

4. Storage Modulus Comparison

Storage modulus reflects the elastic behavior of GelMA under oscillatory stress. It increases with concentration and methacrylation degree.

Concentration (%)	GelMA-30	GelMA-60	GelMA-90
5%	205 ± 20 Pa	1208 ± 95 Pa	2636 ± 263 Pa
10%	1191 ± 119 Pa	4033 ± 411 Pa	9638 ± 960 Pa
15%	5640 ± 700 Pa	17485 ± 1520 Pa	43367 ± 2000 Pa

Figure 3. G' Storage Modulus Following Photocuring



(Oscillation time scan: strain 1%, angular frequency 5 rad/s; 405 nm light, 30 mW/cm², 30 s) Storage modulus increases sharply upon light exposure, indicating rapid photocrosslinking across all GelMA formulations. Final stiffness varies with GelMA concentration and degree of methacrylation.

5. Thermosensitivity Comparison

GelMA exhibits thermoresponsive behavior, meaning it undergoes physical gelation as temperature decreases and reverts to a sol state when warmed. This is particularly useful for support bath printing, mold casting, and maintaining structure prior to light curing.

Phase Inversion Temperature (Cooling/Warming)

Concentration (%)	GelMA-30 (°C)	GelMA-60 (°C)	GelMA-90 (°C)
5%	18.5 ± 1.1 / 28.4 ± 1.3	16.0 ± 0.9 / 28.4 ± 1.3	15.8 ± 1.4 / 27.4 ± 1.5
10%	22.1 ± 1.2 / 30.27 ± 1.2	21.1 ± 1.4 / 30.3 ± 1.4	21.2 ± 1.3 / 29.5 ± 1.0
15%	24.6 ± 1.6 / 31.7 ± 1.7	23.5 ± 1.5 / 31.7 ± 1.7	23.6 ± 1.5 / 30.7 ± 1.7

Phase inversion temperatures represent physical gelation upon cooling and sol reversion upon warming.

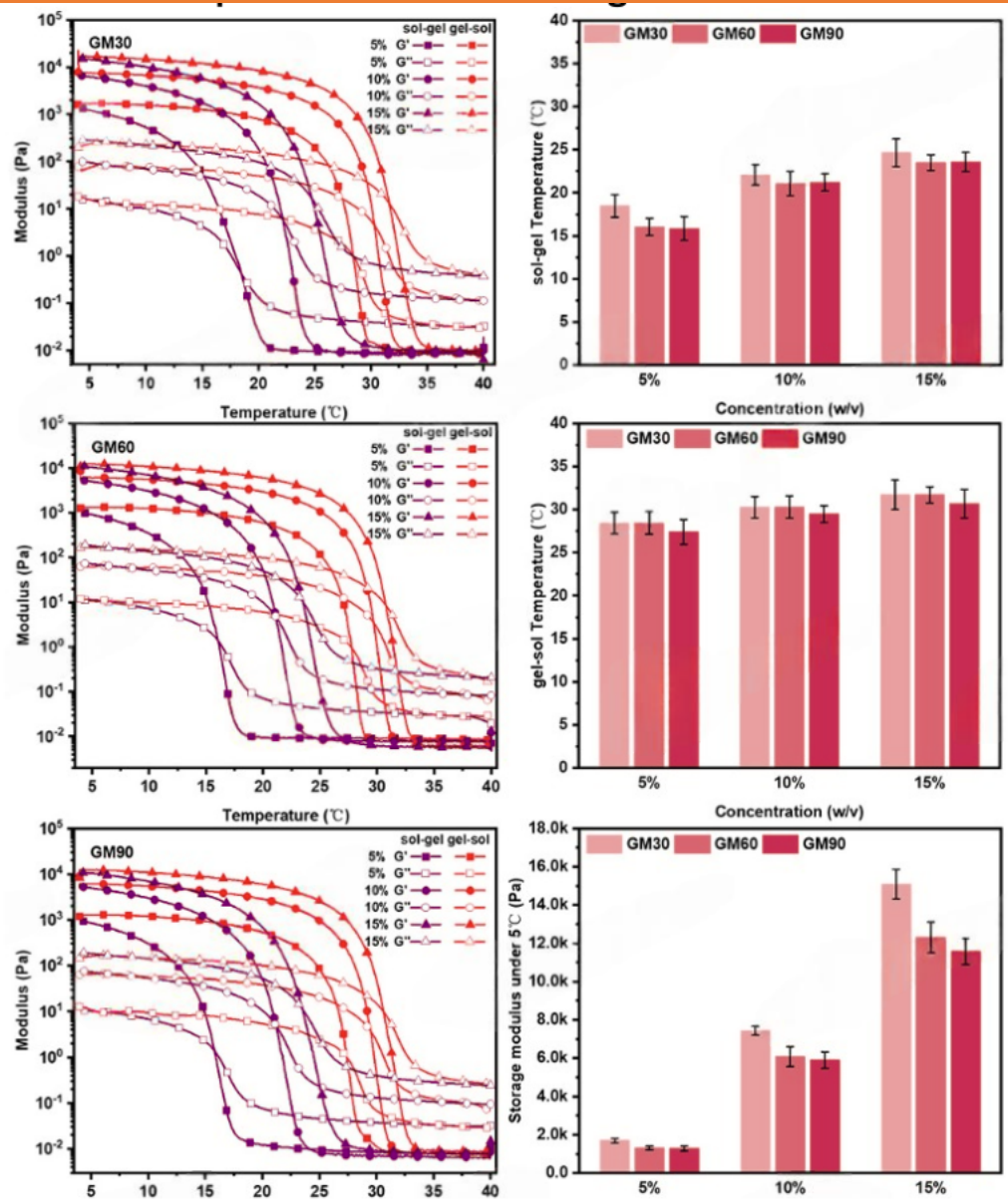
Gel Strength (G') at 5°C (Pa)

At low temperatures (e.g. during cold storage or pre-print handling), GelMA forms a soft gel network even before photopolymerisation. This supports layer stacking, cell settling, and bioink stability.

Concentration (%)	GelMA-30 (Pa)	GelMA-60 (Pa)	GelMA-90 (Pa)
5%	1690 ± 112	1296 ± 95	1278 ± 134
10%	7430 ± 203	6073 ± 413	5899 ± 427
15%	15092 ± 775	12305 ± 796	11570 ± 679

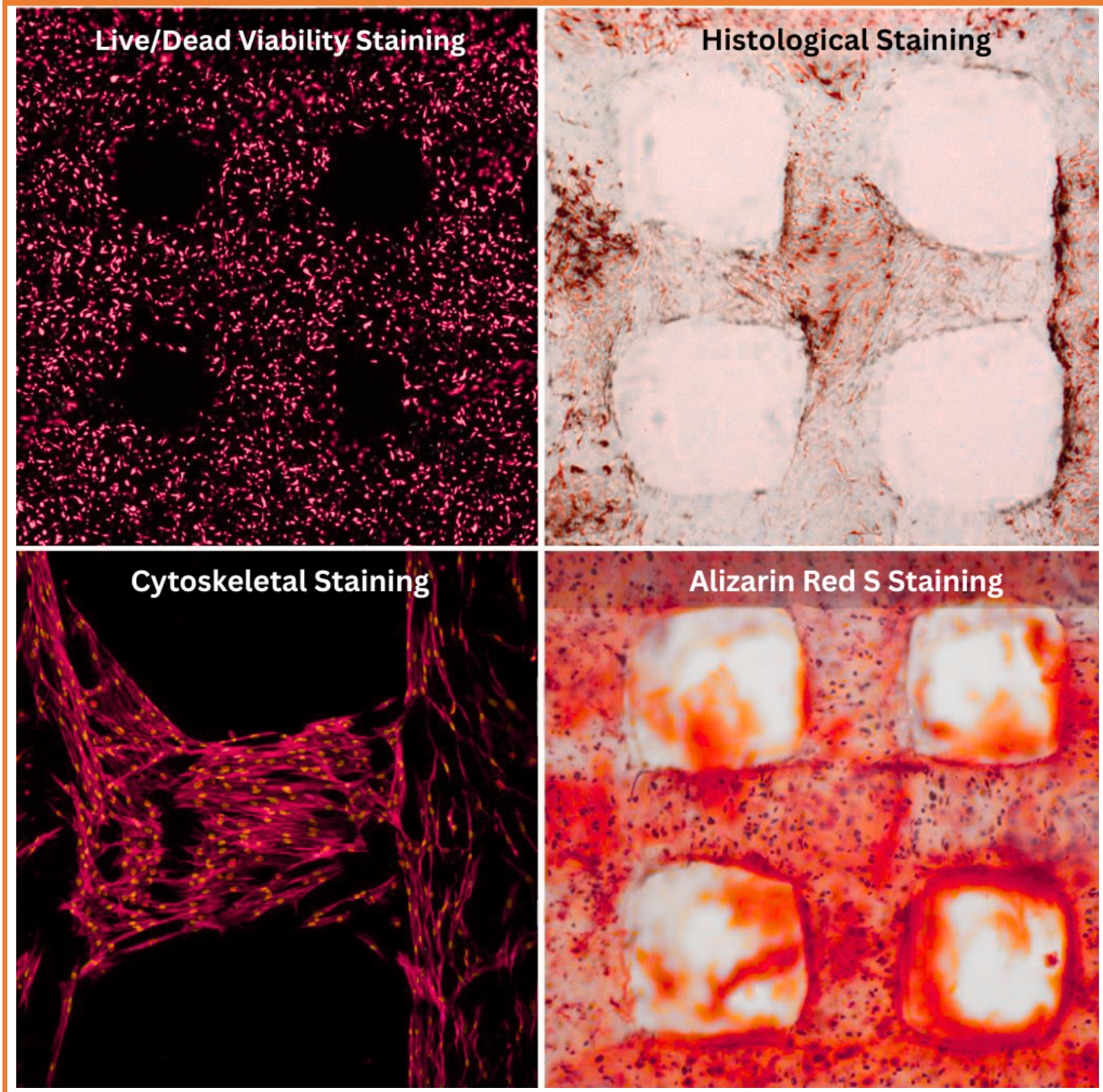
Stronger gel formation at low temperature helps maintain construct shape before light curing.

Figure 4. Rheology of phase transition and gel strength



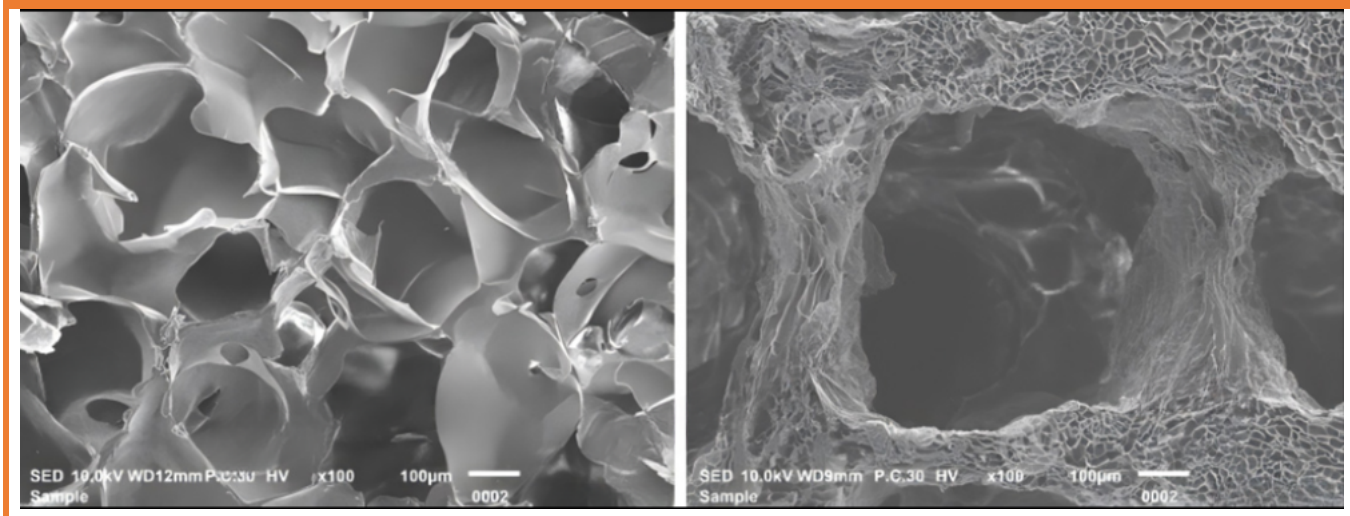
Rheological analysis showing phase transition temperature during cooling and heating cycles and gel strength measured at 5°C. The oscillating temperature scan was performed from 40°C to 4°C and back to 40°C at 5°C/min, with 1% strain and 5 rad/s angular frequency.

Figure 5. 3D Printed GelMA Hydrogel Scaffold with BMSCs



3D bioprinted GelMA hydrogel scaffold encapsulating bone marrow stromal cells (BMSCs), illustrating cell distribution and scaffold structure.

Figure 6. SEM Imaging of Freeze-Dried Hydrogel Samples



Schematic diagram illustrating electron microscopy analysis of freeze-dried hydrogel samples. Left: SEM image of cast hydrogel; Right: SEM image of 3D printed hydrogel scaffold.

Figure 7. 3D printed GelMA hydrogel nose structure for potential use in reconstructive or tissue engineering applications.



This structure was produced using extrusion-based 3D printing of GelMA hydrogel, allowing the fabrication of anatomically relevant, soft tissue constructs for use in cartilage repair or tissue engineering.

Which GelMA Should You Use?

Select the variant that best fits your application needs:

- **GM30 (Low Methacrylation)**
  - Low viscosity — easiest to mix, pipette, or extrude
  - Best for soft tissue models and rapid cell spreading
  - Ideal for composite systems and gentle processing

- **GM60 (Medium Methacrylation)**
  - Balanced stiffness and printability
  - Versatile for vascular, cartilage, and general tissue models
  - Reliable thermosensitivity for mold casting and support baths

- **GM90 (High Methacrylation)**
  - Highest stiffness — forms mechanically stable hydrogels for soft tissue scaffolds and engineered models
  - Reduced swelling — provides improved shape stability for 3D hydrogel structures
  - Suitable for in vitro tissue models, soft tissue load distribution, and 3D bioprinting applications

All types undergo physical gelation at 20–30 °C and photocure efficiently under 405 nm light with LAP.