TWO-PHOTON POLYMERIZATION OF A BIOCOMPATIBLE PHOTOCROSSLINKABLE POLYESTER INTO HOLLOW MICRONEEDLES FOR INTRADERMAL APPLICATIONS

CONTACT

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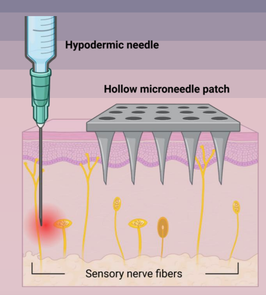
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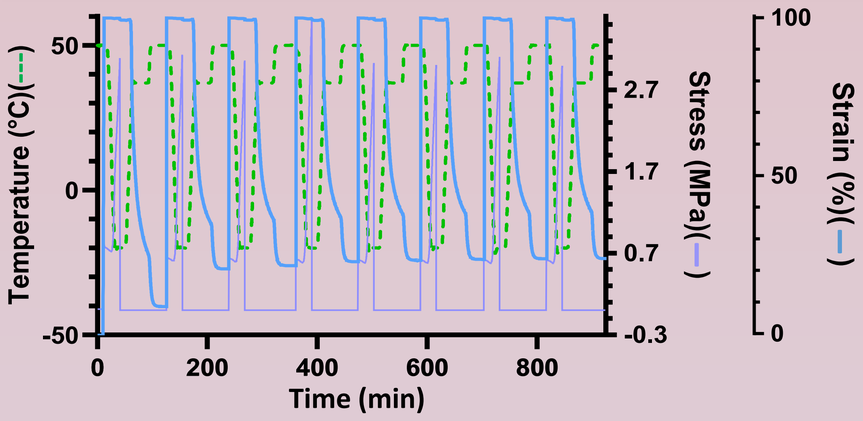
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Background

Hypodermic needles are widely used for drug delivery but are associated with pain, distress, and needle-stick injuries. Microneedles (MNs) offer a minimally invasive alternative by creating microchannels in the skin without stimulating pain receptors, enabling precise local delivery and beneficial wound-healing responses. In this work, a hollow MN patch was fabricated by two-photon polymerization (2PP) using an acrylate-endcapped urethane-based poly(ε-caprolactone-co-δ-valerolactone-co-D,L-lactide) resin. The design, fabrication, and characterization of the device were investigated, while in vitro injection of a fluorescent dye into a GelMA hydrogel demonstrated its potential for future cell therapy, cosmetic, and chronic wound healing applications.



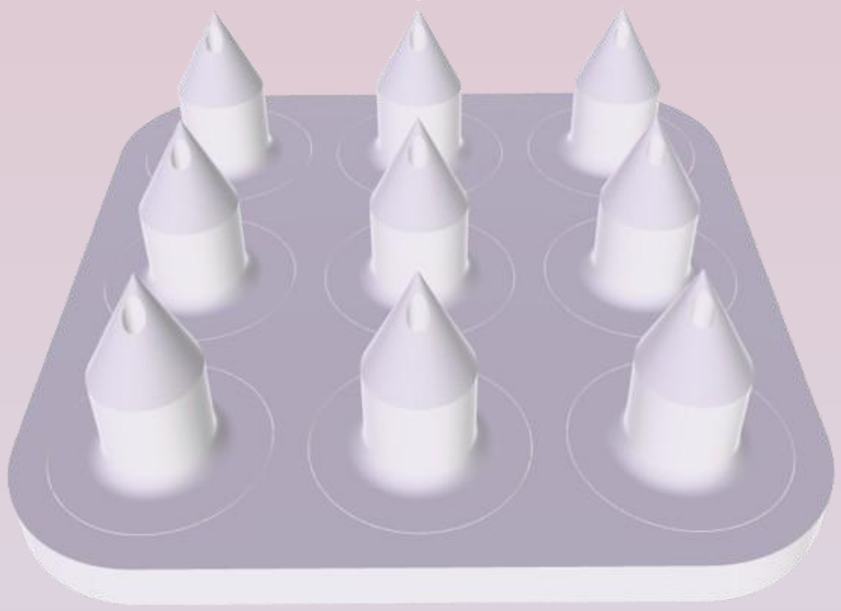
Material properties



Glass temperature (T_g)	± 33.5 °C
Shape recovery/fixity	> 98%
Young's Modulus	1.83 MPa
Gel fraction	94.4 ± 0.1%
Swelling ratio	1.02 ± 0.02

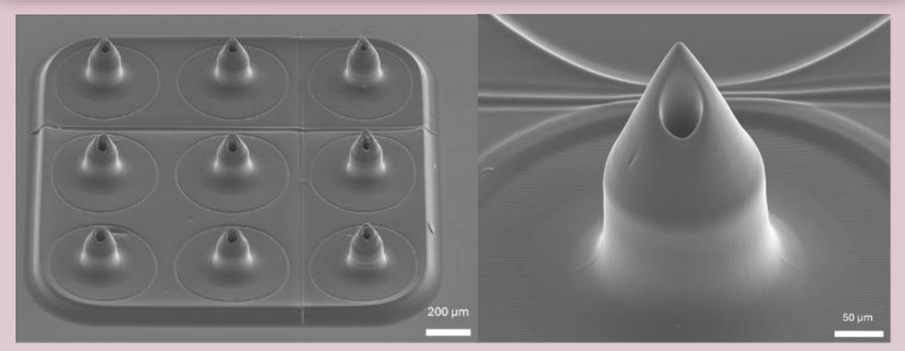
Poly(CL-co-VL-co-DLLA) + Acrylate-endcap
- Transparent
- Biodegradable

- Higher stiffness
- Photopolymerization

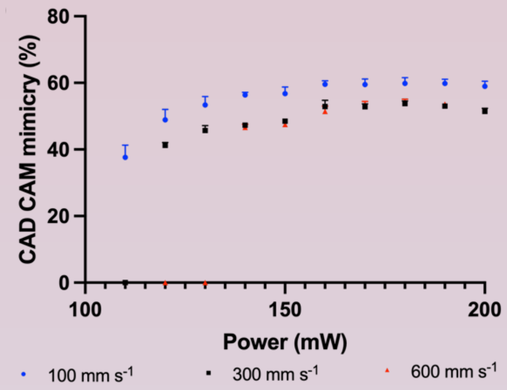


✓ Shape memory behavior near body T
✓ Strong
✓ Near-complete crosslinking
✓ Minimal swelling in PBS

Two-photon polymerization



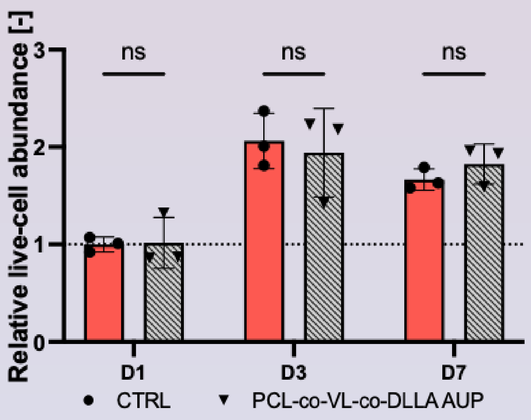
Needle dimensions
✓ Height: 600 µm
✓ Base: 300 µm
✓ Tip: 60 µm

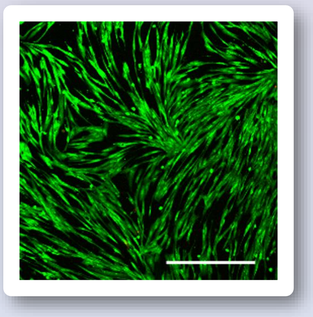


2PP printing parameters
✓ Writing speed: 100 mm/s
✓ Laser power: 180 mW

Biocompatible

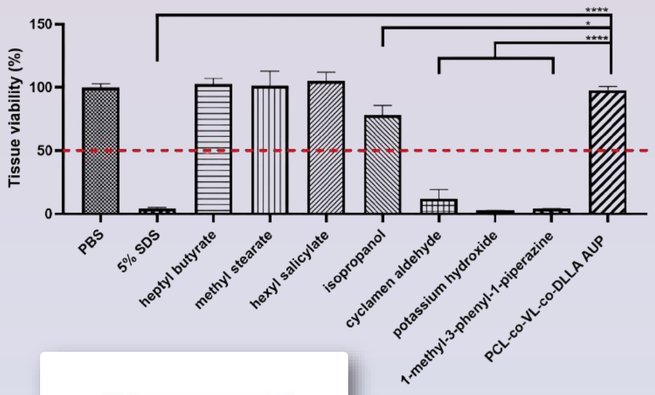
HFFs direct contact

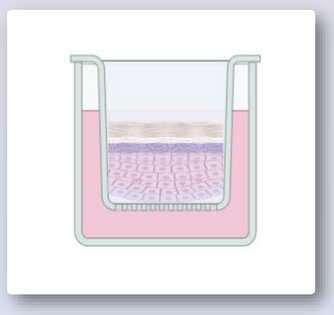




> 80% viability
↑ metabolic activity

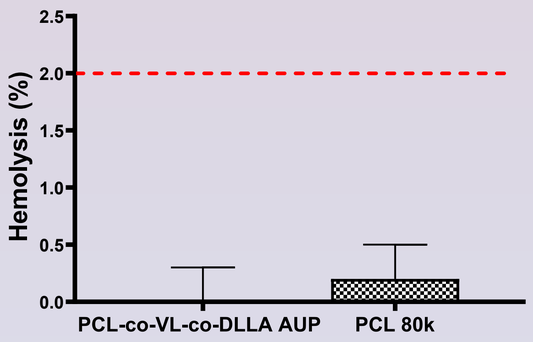
OECD TG 439 Skin Irritation Test

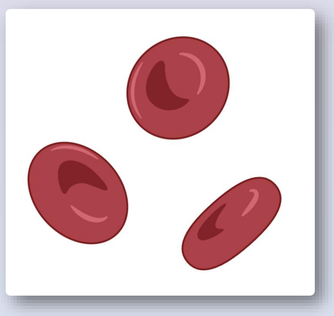




97.8 ± 2.9 % viability
= Non-irritant

Hemolysis assay

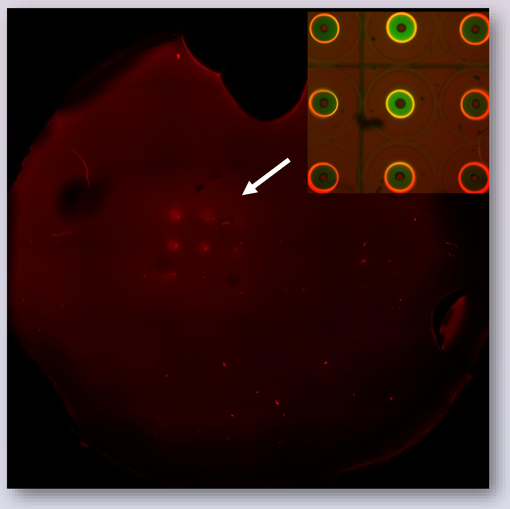




0.0 ± 0.3% < 2%
= Non-hemolytic

Injectable

Dextran-Texas Red loading



48 h soaking in Dextran-Texas Red
↓
24 h insertion into 7.5 wt% GelMA hydrogel
↓
Successful diffusion

Conclusion

✓ Shape memory behavior near body temperature
✓ High crosslinking degree
✓ Low swelling ratio in PBS
✓ Excellent biocompatibility
✓ Freestanding hollow MNs
✓ Injectable

Future perspectives

→ Minimally invasive cosmetic applications
→ Regenerative medicine
→ Drug/vaccine delivery

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