

Design and fabrication of biomimetic four-region drug-loaded cartilage scaffolds with porous hollow fibers

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Innovation and Design

■ Biomimetic Design:

A novel design inspired by the four distinct regions of native cartilage, mimicking its structure and mechanical properties.

■ Materials:

A novel ink formulation with excellent self-supporting properties for 3D printing.

■ Drug Delivery System:

Scaffold integrated with a hollow porous fiber network, providing stable drug release performance.

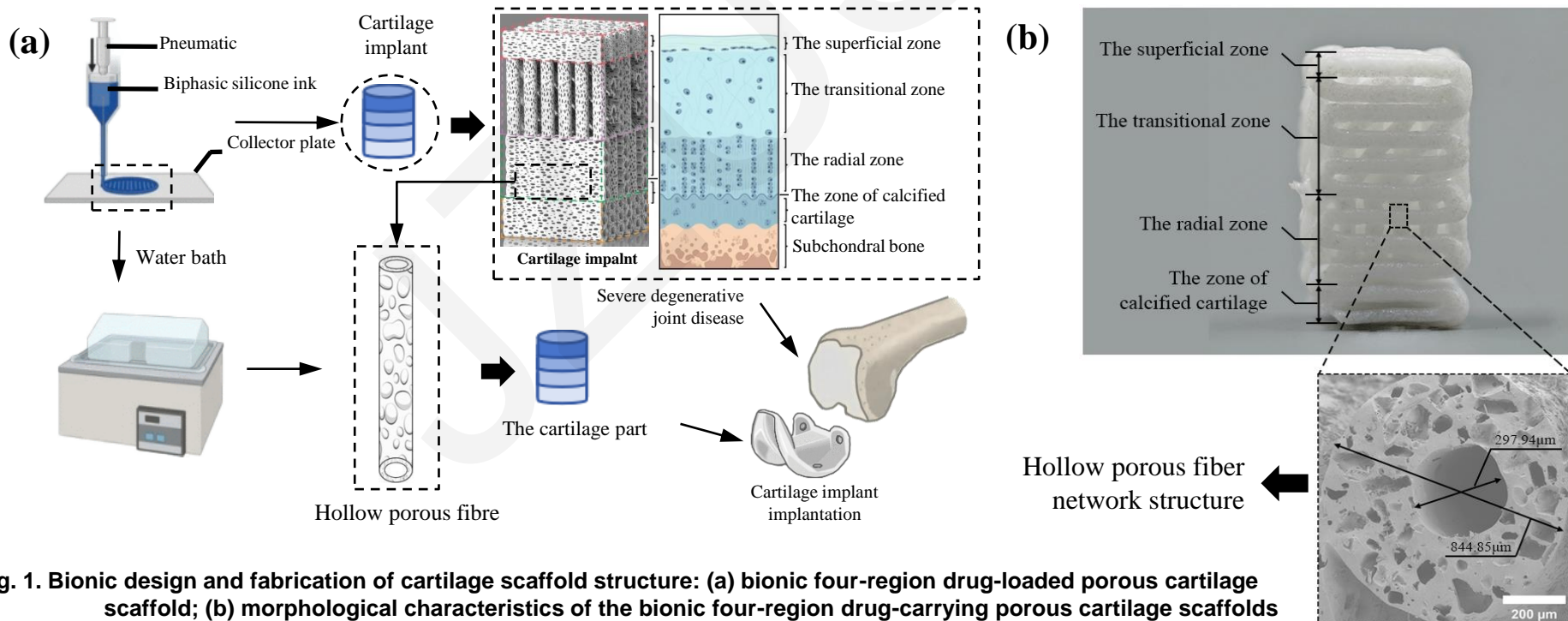


Fig. 1. Bionic design and fabrication of cartilage scaffold structure: (a) bionic four-region drug-loaded porous cartilage scaffold; (b) morphological characteristics of the bionic four-region drug-carrying porous cartilage scaffolds

Key Results

■ Mechanical Properties:



Biphasic silicone ink



Good printability

High self-supporting performance

Influence of Structural Parameters:

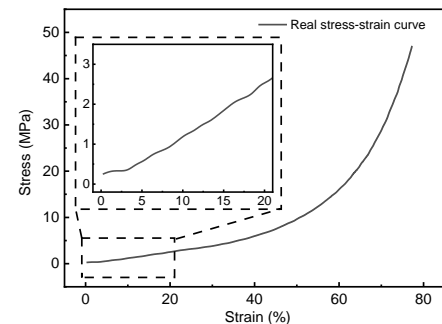
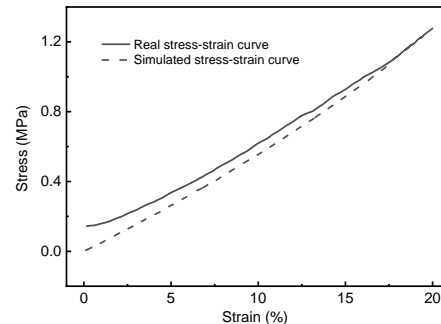
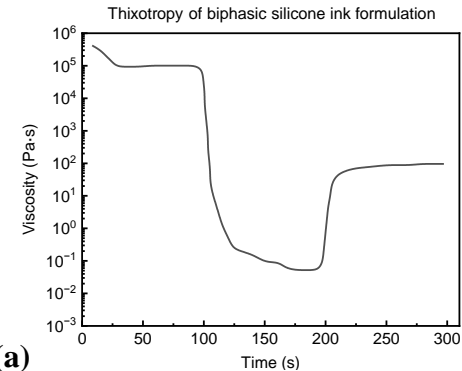
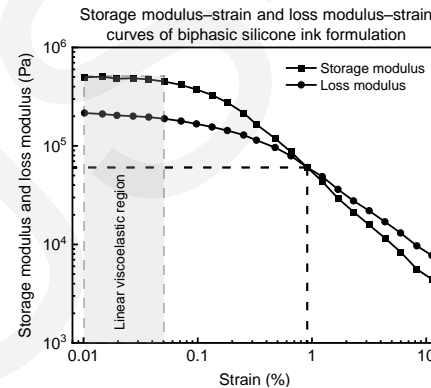
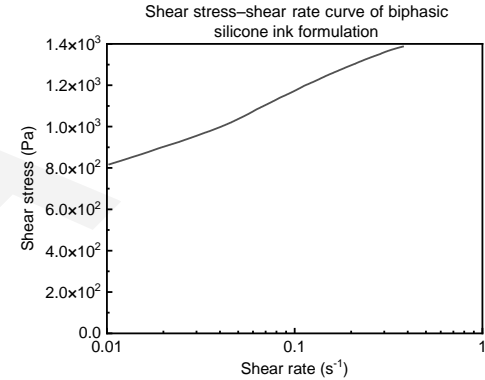
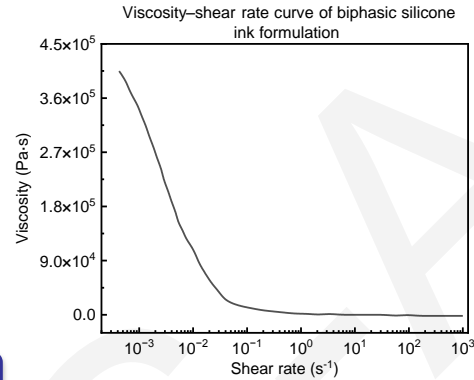
The effects of fiber parameters followed a clear order of significance: **fiber diameter > fiber spacing > fiber orientation angle.**

High Agreement Between Simulation and Experiment:

Real vs. simulated stress-strain curves show high correlation.

Compression Modulus:

Scaffold's mechanical properties closely match native cartilage.



(b)

(c)

Fig. 2. Bionic design and fabrication of cartilage scaffold structure: (a) rheological properties of the biphasic silicone ink formulation; (b) comparison between the actual stress-strain curve within a small range of strain and the simulated stress-strain curve; (c) real stress-strain curve of the bionic four-region drug-loaded porous cartilage scaffold.

Key Results

■ Drug Release and Biocompatibility:

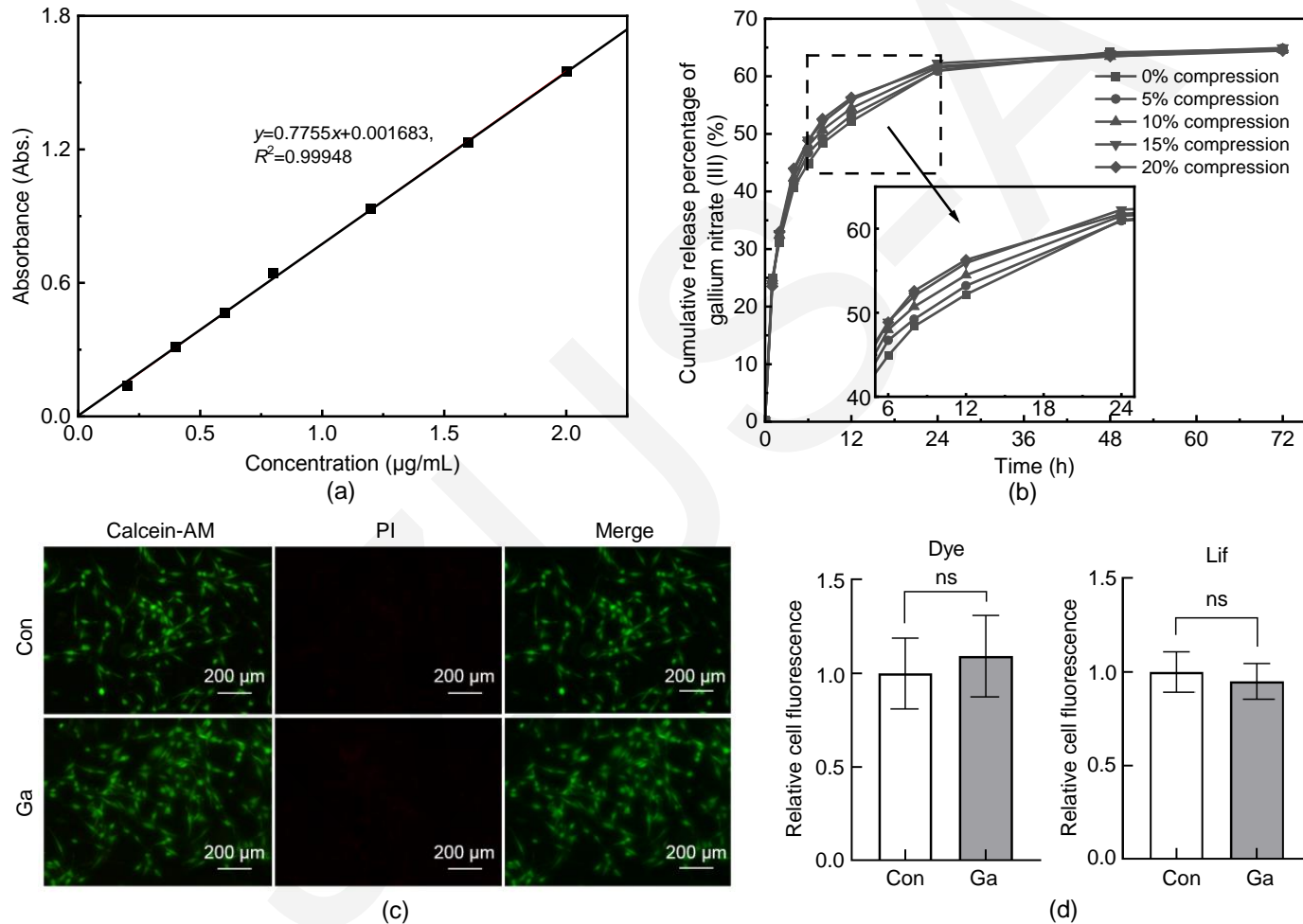


Fig. 3. Characterization of drug loading, sustained drug release performance, and biocompatibility of the cartilage scaffold: (a) standard curve of gallium (III) nitrate complex at the maximum absorption peak; (b) time curve of cumulative percentage release of gallium (III) nitrate; (c) live/dead staining fluorescence microscope images of human chondrosarcoma cells cultured on a cartilage scaffold for 48 h; (d) Proliferation of chondrocyte on Ga-ion-carrying cartilage scaffold. Error bars represent S.D., and significant differences were assessed with Student's t-test; *P < 0.05.

Conclusions

■ Conclusion:

The biomimetic four-region cartilage scaffold provides a promising solution for cartilage defect treatment, offering mechanical and drug delivery properties that match native tissue.

■ Future Challenges:

- Scaling production for clinical use.
- Incorporating additional properties like wear resistance and lubrication for better performance.
- Further in-vivo studies are needed to confirm long-term biocompatibility and effectiveness.