ACCSCIENCE PUBLISHING

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RESEARCH ARTICLE

Boronate ester–crosslinked GelMA composite bioink for 3D bioprinting of cell-laden corneal stroma and *in vivo* evaluation in rabbits

Supplementary File

Table S1. DoF of GelMA determined using the TNBS assay

No.	DoF (%)
1	52.29
2	53.34
3	54.21
Average	53.28

Abbreviations: DoF: Degree of functionalization; GelMA: Gelatin methacryloyl; TNBS: 2,4,6-trinitrobenzenesulfonic acid.

Table S2. Swelling ratios of lyophilized 10% GelMA, 10% GelMA with 10% PBA@G, and 10% GelMA with 10% PBA@G and 1% PVA

Sample	10% GelMA (%)	10% GelMA with 10% PBA@G (%)	10% GelMA with 10% PBA@G and 1% PVA (%)
1	1,227.39	731.07	493.69
2	1,061.43	706.17	652.04
3	1,114.81	698.59	683.11
Average	1,134.54±84.72	711.94±16.99	609.61±101.59

Abbreviations: GelMA: Gelatin methacryloyl; PBA@G: Phenylboronic acid-functionalized gelatin; PVA: Poly(vinyl alcohol).

Table S3. Primer sequences used for quantitative real-time polymerase chain reaction

Gene	Forward primer (5'-3')	Reverse primer (5'-3')
ACTA2	CTATGCCTCTGGACGCACAACT	CAGATCCAGACGCATGATGGCA
ALDH3A1	CTCGTCATTGGCACCTGGAACT	CTCGCCATGTTCTCACTCAGCT
ACTB	CACCATTGGCAATGAGCGGTTC	AGGTCTTTGCGGATGTCCACGT

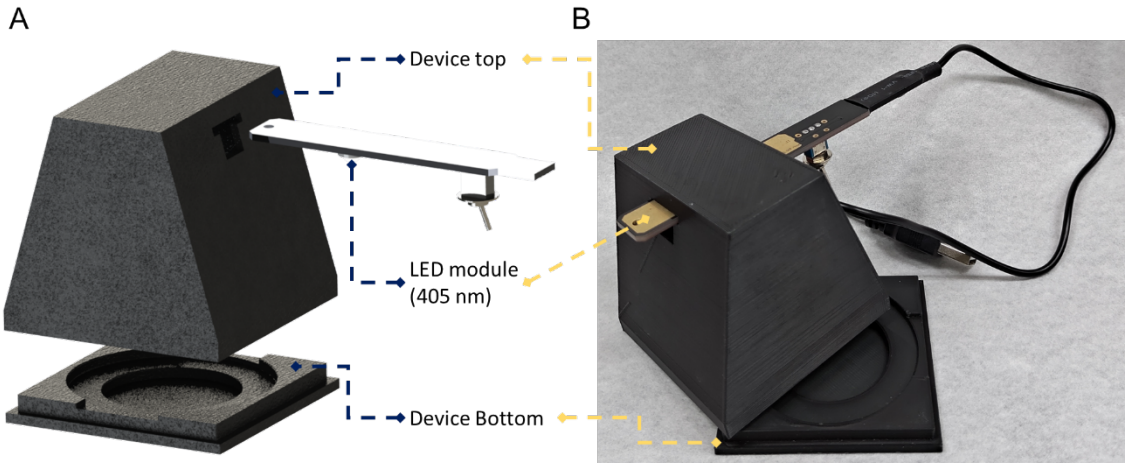

Figure S1. Design (A) and photograph (B) of the proposed 3D-printed UV-light-emitting diode (LED) device

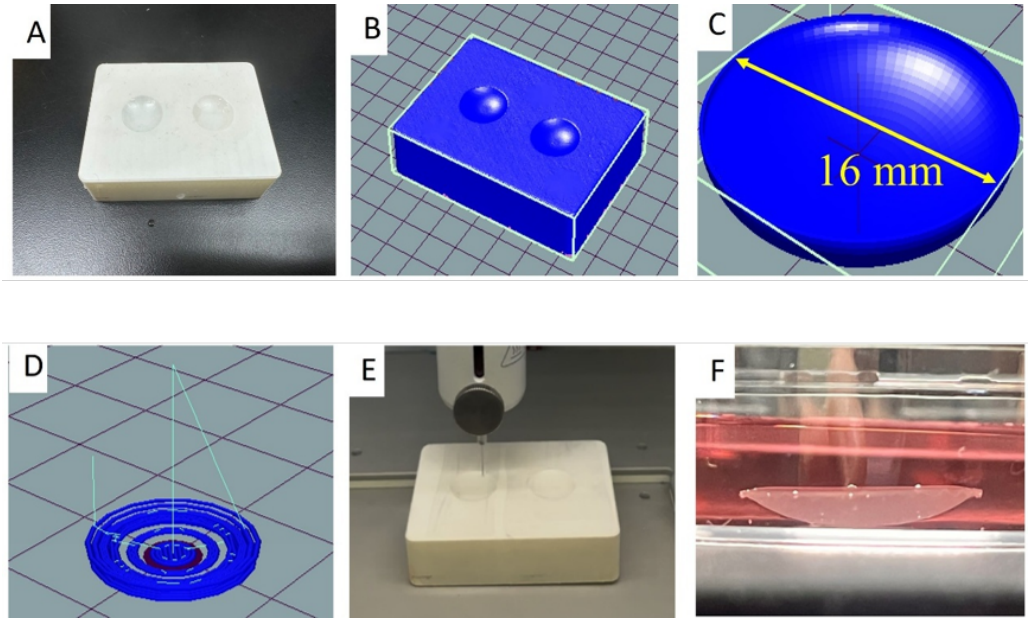

Figure S2. The artificial cornea was printed with a BioX 3D printer. (A) Corneal mold used as the basis for digital reconstruction. (B) Digitized image generated from the scanned corneal mold. (C) Reverse-engineered digital model of the artificial cornea generated using 3D modeling software; the 16-mm model dimension is distinct from the 8.5-mm surgical trephination diameter used in the rabbit anterior lamellar keratectomy procedure. (D) G-code simulation of the printing path, starting from the center and proceeding outward in concentric circles. (E) During printing, 365-nm UV irradiation was applied for 10 s after each full circle. (F) Transparent, concave-shaped artificial corneal construct printed as a single layer using a 25 G blunt needle with a 0.41-mm nozzle diameter and a programmed layer height of 0.205 mm; the completed construct was photocrosslinked at 365 nm for 120 s.

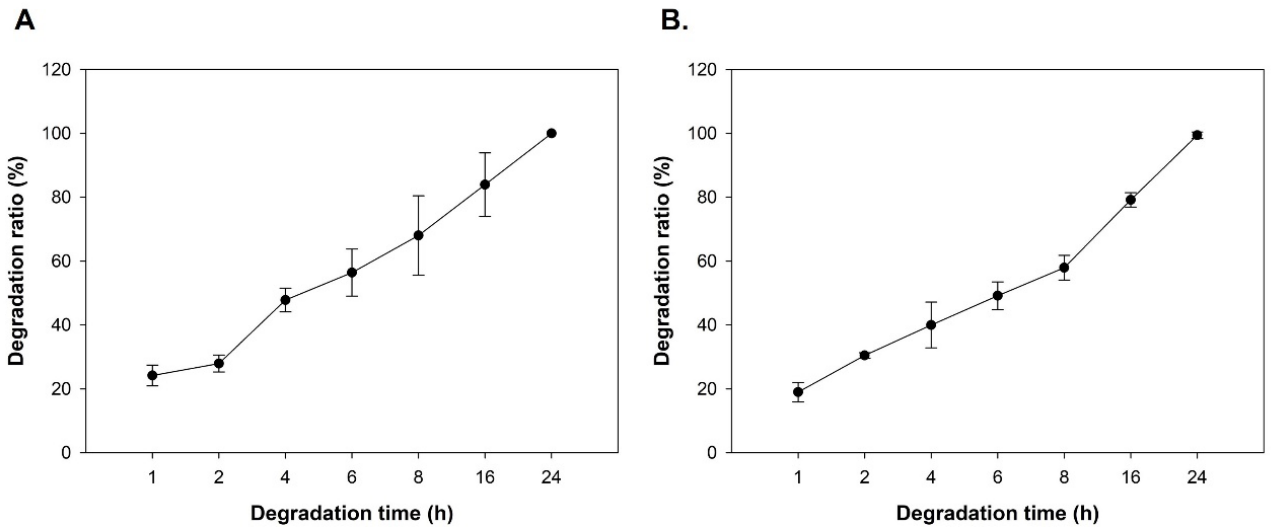

Figure S3. Degradation rates of (A) 10% gelatin methacryloyl (GelMA) and (B) 10G10P

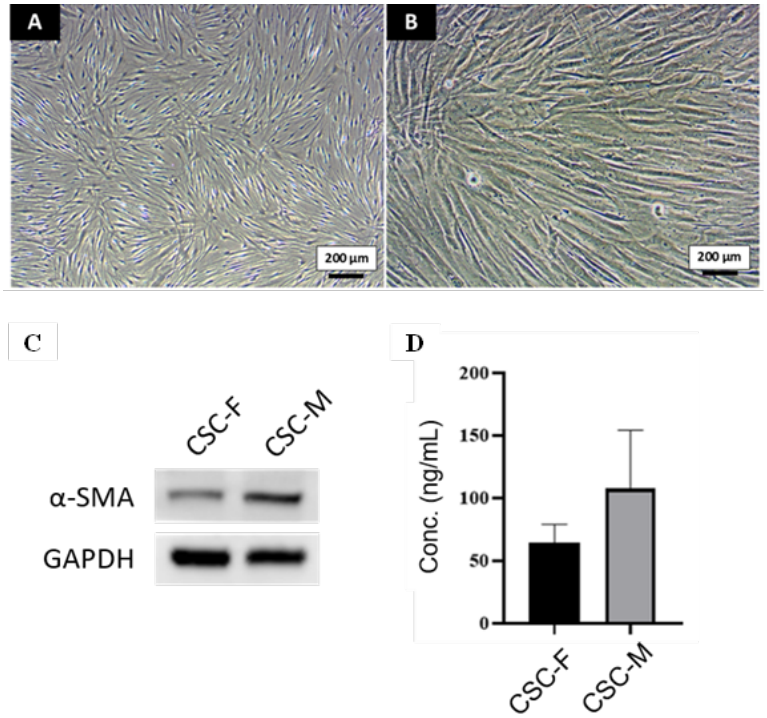

Figure S4. Characterization of corneal stromal cell (CSC) reference states. Representative morphology of (A) CSC-F cultured under conditions intended to limit myofibroblastic activation and (B) myofibroblast-like CSC-M. Scale bar: 200 µm; magnification: 100×. (C) Alpha-smooth muscle actin (α-SMA) protein expression in CSC-F and CSC-M. (D) Matrix metalloproteinase-2 (MMP-2) levels in culture media from CSC-F and CSC-M. These *in vitro* reference states were used for phenotype-associated comparison and were not measurements of molecular expression in rabbit corneal tissue after implantation.