Supplementary Information (SI) for Green Chemistry.
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Supporting Information

Caffeine-Catalyzed Synthesis of Photopolymers for Digital Light Processing

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MATERIALS AND METHODS

All chemicals were purchased from Sigma Aldrich and Oakwood Chemical and used without purification unless noted otherwise. Polycaprolactone diol (bPCL, M_n = 530 g/mol) and polycaprolactone triol (tPCL, M_n = 900 g/mol) were from Placcel Inc. NMR spectra were recorded on a Bruker AV III HD 500 MHz spectrometer with a broadband Prodigy cryoprobe or Varian INOVA 400 MHz spectrometer. $CDCl_3$ was used as the NMR solvent. Differential Scanning Calorimetry (DSC) was conducted on a TA Instruments Q1000 Modulated Differential Scanning Calorimeter to determine glass transition temperature (T_g). Scanning electron microscopy (SEM) was conducted on a Jeol JCM-7000 benchtop SEM.

All error bars represent the standard error of an n=3 sample size. Statistical significance is determined via Student's t-test.

Photopolymer Characterization

Macromers were characterized via ^{1}H NMR. Photopolymer viscosity and photo-cross-linking behaviors were measured on the TA Rheometer. Cured photopolymer properties were measured with DSC and uniaxial tensile testing, all according to our previous protocol.[1]

Aorta 3D Model Generation

Anonymized patient CT angiography DICOM data was segmented and converted to a 3D model using STL language according to our previous protocol.[2]

***In Vitro* Cytocompatibility**

The study was conducted according to our previous protocol.[1] To prepare thin films for cytocompatibility study, 6-mm glass coverslips were briefly dipped in 1 wt % solution PCL (in chloroform) or thiol-norbornene photopolymer (in acetone). After air-drying overnight, the coverslips were incubated under ultraviolet light (Asiga Flash UV Curing Chamber) for thirty minutes. They were then placed in 24-well plates and washed three times with 100% ethanol for twenty minutes per wash. The *in vitro* cytocompatibility test was performed using Human umbilical vein endothelial cells (HUVEC, C2519A, Lonza, MD). HUVECs (passages 4-6) were cultured using an endothelial cell growth medium MV 2 kit that contained 5% Fetal Bovine Serum and supplements (C-22121, PromoCell/VWR, PA). The cells were harvested using trypsin-EDTA after reaching confluency, neutralized with medium, centrifuged at 200g for 5 minutes, and resuspended to obtain 10^4 cells/mL. 50 µL of the suspension (500 cells/50 µL) was added dropwise onto the coverslips and the cells were incubated for 3 h before 1mL of the medium was added to each well. Cells were incubated at 37 °C with 100% humidity and 5% CO2. The medium was

exchanged every 48 h. Cell Titer Glo 2.0 assay kit (G9241, Promega, WI) was used to measure the luminescence of the amount of ATP present, which indicated the presence of metabolically active cells after 1, 2, 3, and 4 days. The luminescence (Relative Light Units (RLU)) was recorded using a SpectraMax M3 microplate reader (Molecular Devices, CA). A Live assay was performed on days 1-4 using Calcein-AM (C3100MP, Invitrogen, NY). Live cells were identified when calcein-AM in medium (1μM final concentration) was converted to green fluorescence after interacting with intracellular esterases. The fluorescent images were observed using a Nikon ECLIPSE Ti fluorescence microscope (Nikon Instruments INC., NY).

***In Vivo* Biocompatibility**

The study was conducted according to an approved protocol (Cornell University IACUC protocol number: 2017-0118).[3] Ethylene oxide-sterilized tPCL-CA-PO implants (diameter of 6 mm and thickness of 1 mm) were implanted in 2 female BALB/cJ mice (Jackson Laboratory) with an average age of 8-9 weeks. Under deep isoflurane-O_2 general anesthesia, the samples were implanted subcutaneously in the back of the mice by blunt dissection. After 14 days the animals were sacrificed and tissues (~15 × 15 mm) surrounding the implants were harvested with the intact implants. Tissues were fixed in 4% paraformaldehyde for 1.5 hours and soaked in 30% sucrose for 48 hours and embedded in Shandon™ Cryomatrix™ embedding resin (Thermo Scientific™).

Serial cross-sections at the center, quarter and edge of each implant (8 μm thick, longitudinal axial cut) were stained with hematoxylin and eosin (H & E) to examine host responses such as inflammation and other adverse effects. All reagents for H & E staining were obtained from Electron Microscopy Sciences, PA, USA. All imaging was performed on a Nikon Eclipse Ti2-E inverted microscope, and image analysis was performed with NIS Elements software (Tokyo, Japan).

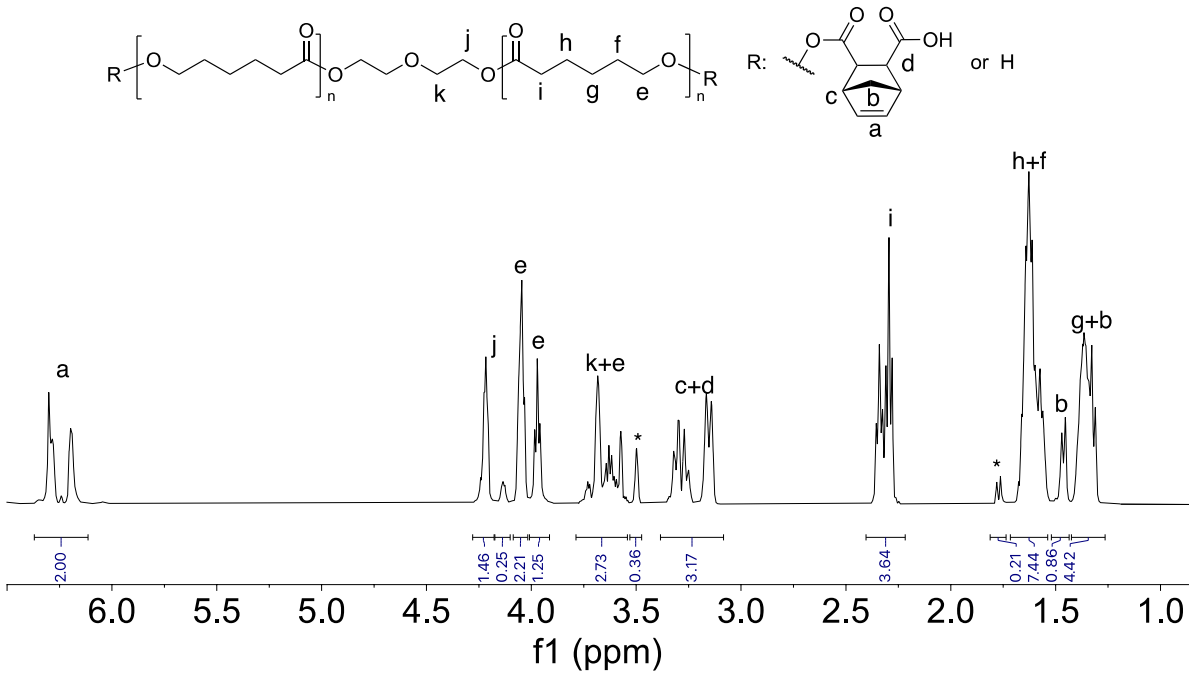

Figure S1: ^{1}H-NMR ($CDCl_3$, 500 MHz) of bPCL-CA. * is from the methylene proton of unreacted CA monomer.

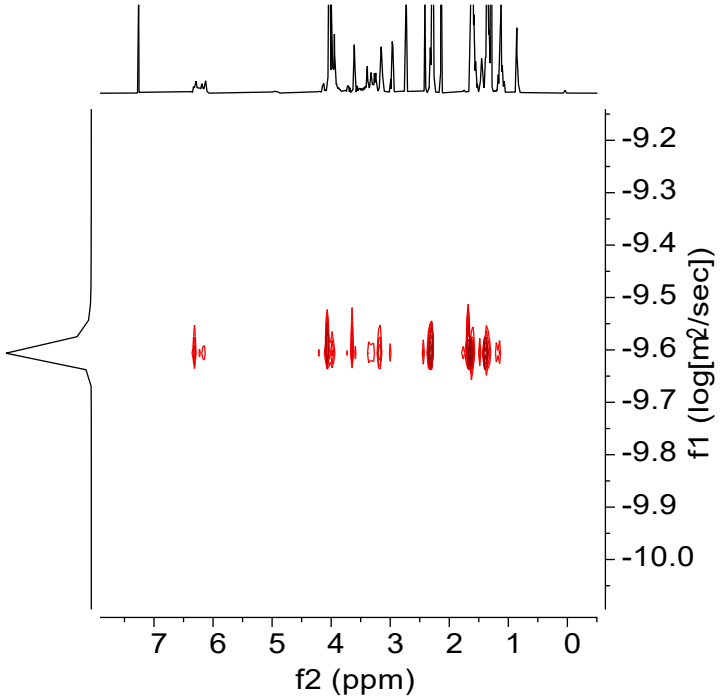

Figure S2: Diffusion NMR ($CDCl_3$, 500 MHz) of tPCL-CA-PO100.

SUPPORTING FIGURES

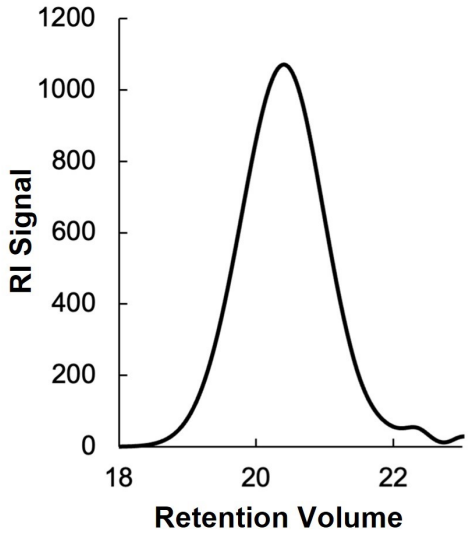

Figure S3: GPC trace of tPCL-CA-PO41.

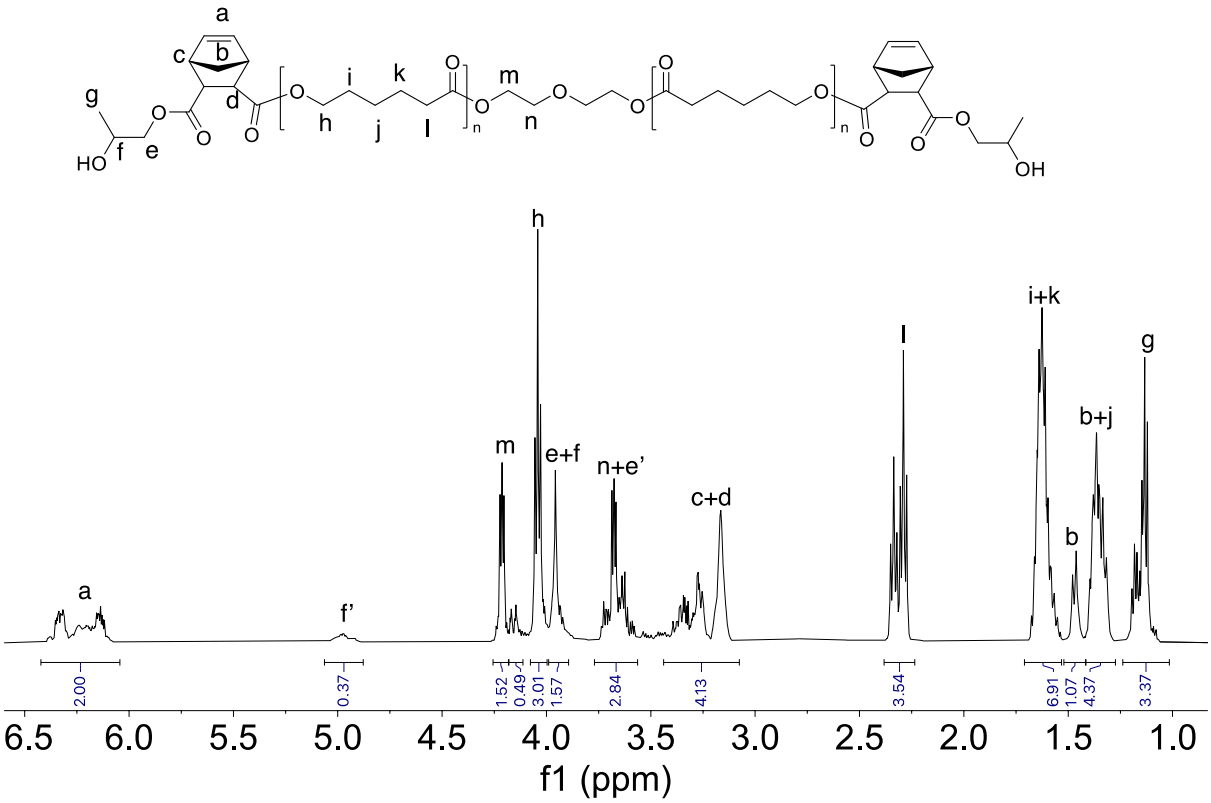

Figure S4: ^{1}H-NMR of bPCL-CA-PO100. e' and f' are from PO ring-opened at the tertiary carbon.

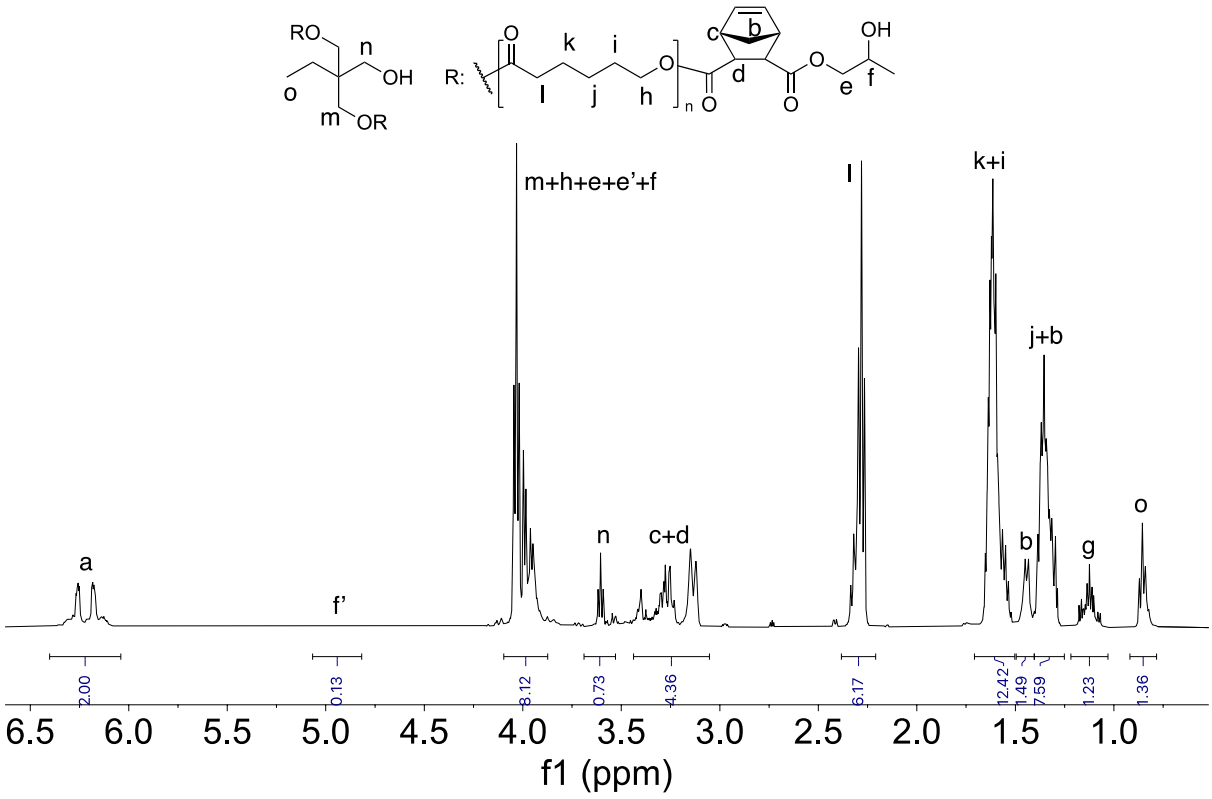

Figure S5: ^{1}H-NMR of tPCL-CA-PO100. e' and f' are from PO ring-opened at the tertiary carbon.

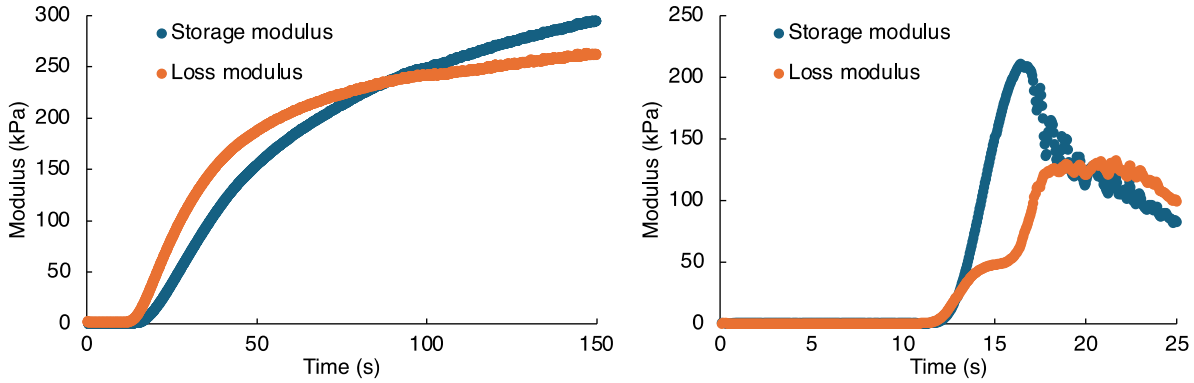

Figure S6: Photorheology of bPCL-CA resin (left) and bPCL-CA-PO100 resin (right). The UV source is equipped with a 400-500 nm filter. And the UV irradiation starts at t=10s. bPCL-CA displays a slower increase in storage modulus and loss modulus, signifying a slow rate of cross-linking.

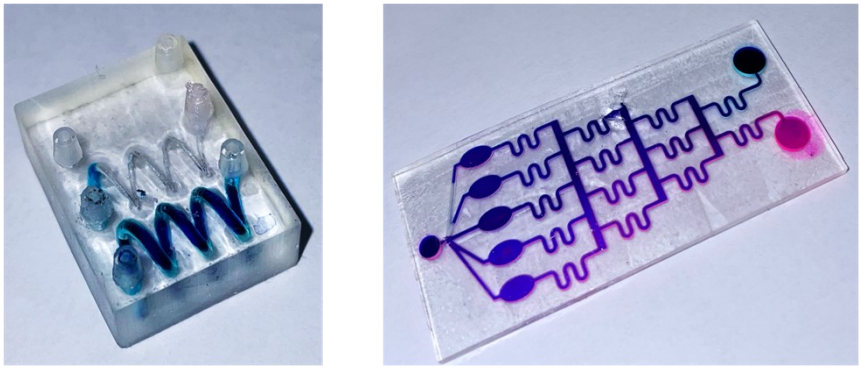

Figure S7: 3D printed microfluidic devices. (Left) cork-screw-shaped channels with progressively smaller diameter (bottom to top: 1mm, 500 µm, 250 µm). (Right) A simple "2D" mixing device (the widest channel is 1 mm in diameter, source: https://www.thingiverse.com/thing:3312176). Patent channels are visualized with food dye.

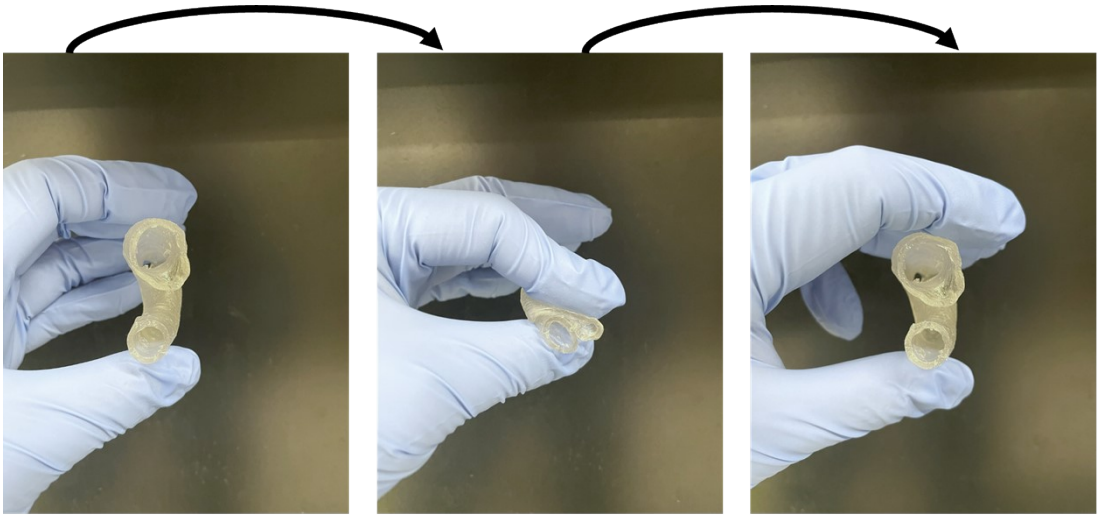

Figure S8: Bottom view and manipulation of DLP-printed aorta model.

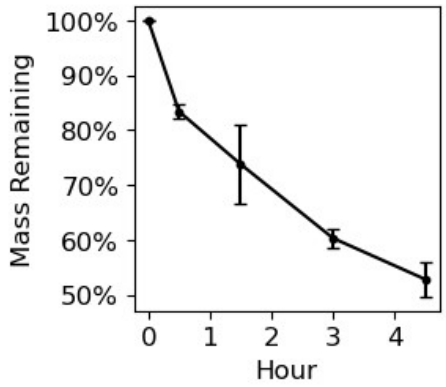

Figure S9: Degradation of bPCL-CA network (n=3) in 60 mM NaOH at 37 °C.

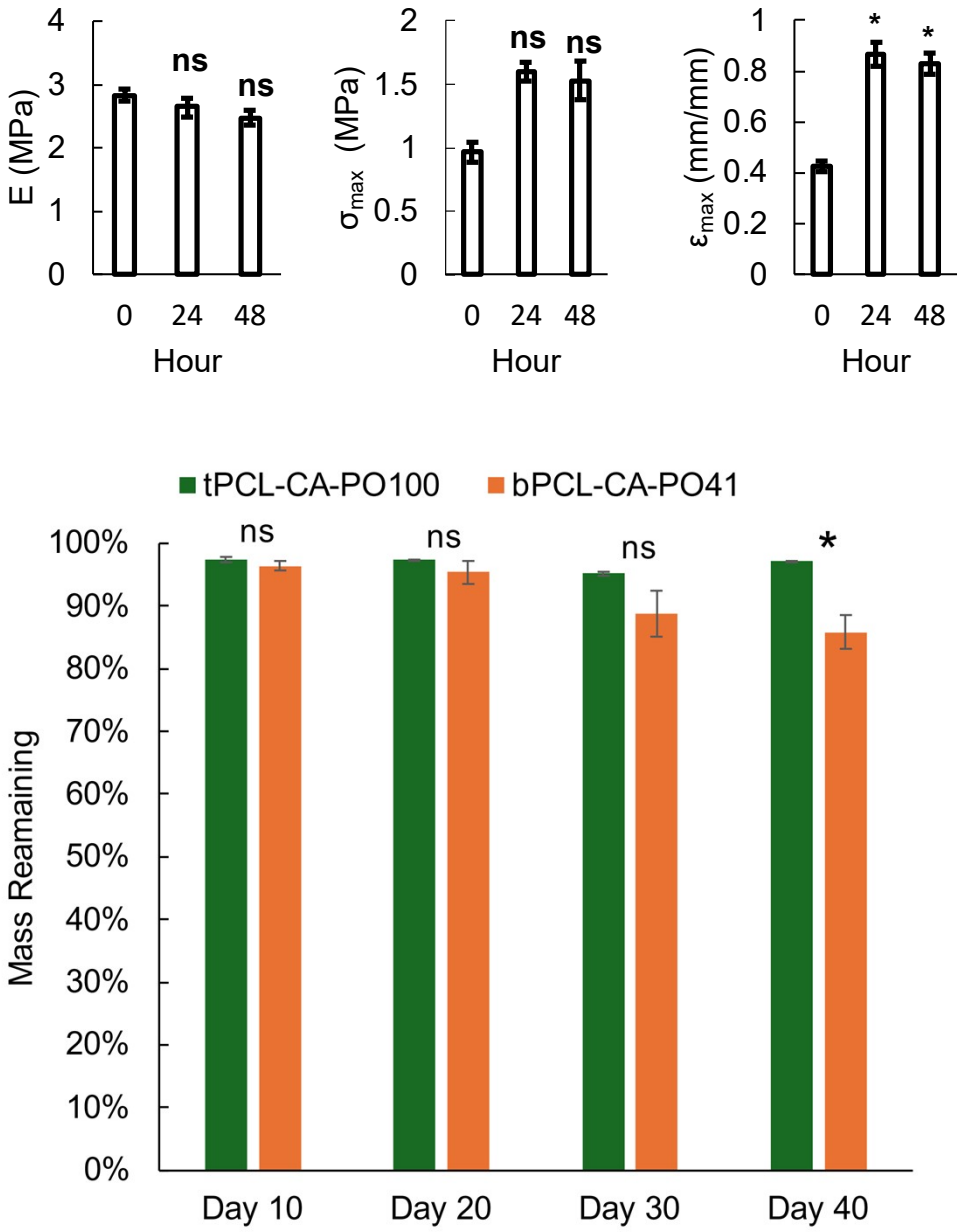

Figure S10: (Top) Change of bPCL-CA-PO100 network's mechanical properties throughout degradation in 0.25 M NaOH at 37 °C (n=3, ns: not significant, * $p<0.05$). (Bottom) *In vitro* degradation of tPCL-CA-PO100 and bPCL-CA-PO41 in Dulbecco's Phosphate Buffered Saline (n=3, ns: not significant, * $p<0.05$). Statistical significance is determined via Student's t-test.

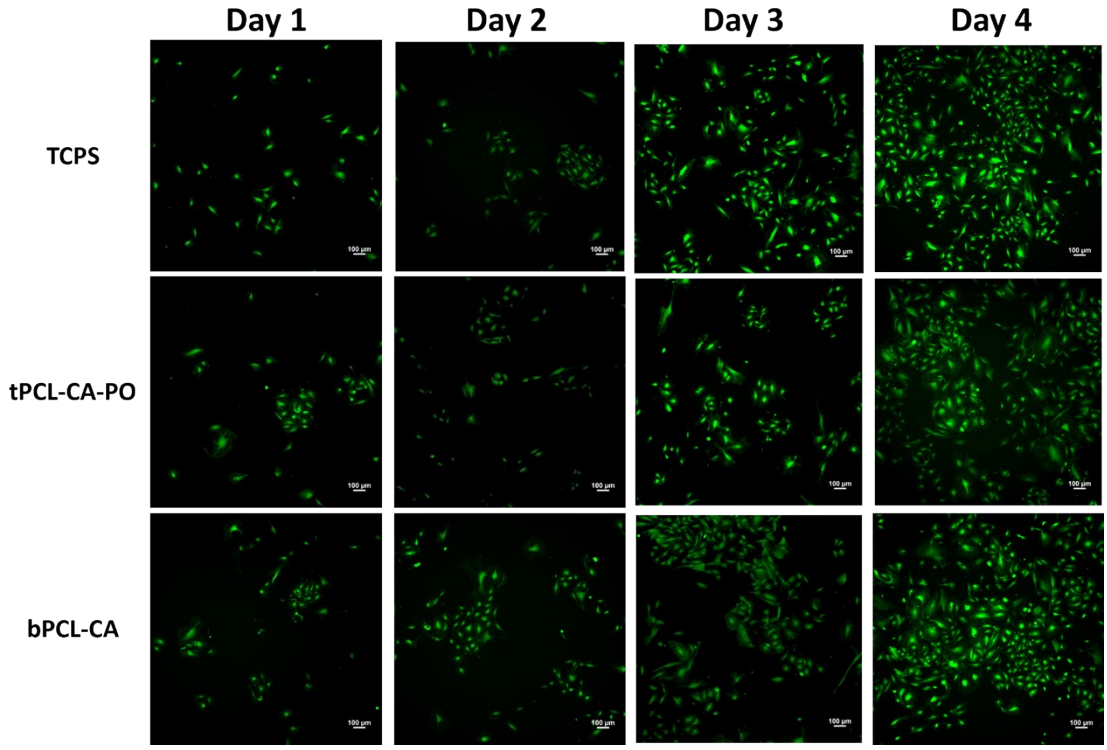

Figure S11: Calcein-AM staining of HUVECs on various samples (scale bar: 100 μm).

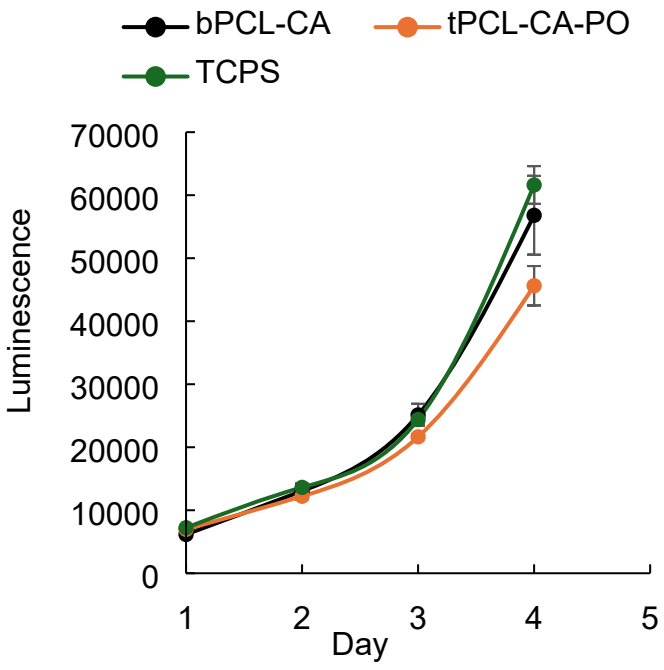

Figure S12: Growth curves of HUVECs on various samples. TCPS: tissue-culture-treated polystyrene.

REFERENCES

(1) Ma, W. R.; Miller, P. G.; Wang, Y. D. ABA Block Copolyester Thiol-Ene Resin From Triethylborane-Assisted Ring-Opening Copolymerization. *Acs Appl. Polym. Mater.* **2024**, *6* (2), 1503-1513. DOI: 10.1021/acsapm.3c02745.
(2) Ma, W.; Wright, N.; Wang, Y. Norbornene Dicarboximide: A Green Alternative for Thiol-Norbornene Photopolymers. *Acs Macro Lett.* **2024**, 915-920. DOI: 10.1021/acsmacrolett.4c00334.
(3) Chen, Y.; Miller, P. G.; Ding, X. C.; Stowell, C. E. T.; Kelly, K. M.; Wang, Y. D. Chelation Crosslinking of Biodegradable Elastomers. *Adv. Mater.* **2020**, *32* (43). DOI: ARTN 2003761 10.1002/adma.202003761.