Pamela C. Cai

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Summary

Materials scientist bridging fundamental polymer physics, computational modeling, and quantitative experimentation. Author of 12 peer-reviewed publications and recipient of multiple research awards, currently leading a research program developing polymeric materials for cryopreservation.

Work Experience

Until Labs, Senior Polymer Scientist — South San Francisco, CA
Applied Physics & Materials — 2025–

- Develop **molecular simulations** to investigate cryoprotective materials and inform experimental design
- Integrate **physics-based modeling** with experimental characterization to guide organ preservation strategies
- Lead interdisciplinary research in **polymeric cryoprotective materials**, directly managing two research staff and overseeing experimental strategy and execution

University of Chicago, Arnold O. Beckman Postdoctoral Fellow — Chicago, IL
Pritzker School of Molecular Engineering, Lab of Prof. Matthew Tirrell — 2023–2025

- Engineered **biodegradable, recyclable biopolymer materials** through polyelectrolyte complexation, achieving 98% mass retention through 6 recycling cycles
- Derived and implemented a physics-based computational model of charged polymer fluids using **high-performance computing**

Stanford University, NSF Graduate Research Fellow & Stanford Bio-X Fellow — Stanford, CA
Department of Chemical Engineering, Labs of Profs. Andrew Spakowitz and Sarah Heilshorn — 2018–2023

- Derived and experimentally validated **polymer physics theory** linking molecular association dynamics to macroscopic viscoelasticity, establishing quantitative design rules for dynamic polymer networks
- Built **open-source software** for dynamic light scattering microrheology, enabling characterization of soft and living materials across six orders of magnitude in time
- Developed **biophysical models** of antibiotic diffusion in complex biological environments to explain tolerance

Morgan Stanley, Exotic Derivatives Analyst — New York, NY
Institutional Equities Division, Financial Engineering — 2016–2018

- Built 300+ quantitative pricing models of complex derivatives using Monte Carlo simulations; worked with trading and quantitative teams to turn mathematical predictions into decisions

Education

Stanford University — Stanford, CA
Ph.D. in Chemical Engineering — 2018–2023

Massachusetts Institute of Technology (MIT) — Cambridge, MA
B.S. in Chemical Engineering, Minor in Music Performance and Theory — 2012–2016

Technical Skills

Data Analysis & Modeling: Python, R, JAX, MATLAB, polymer physics theory, molecular dynamics, Monte Carlo simulation, statistical analysis
Experimental: DLS, GPC/SEC-MALS, FTIR, NMR, DMA, DSC, TGA, ITC, rheology, UV-Vis, microscopy, polymer synthesis and processing, cell-based assays

Selected Publications (6 of 12)

**co-first authors*

1. **PC Cai**, V Vaz, and MV Tirrell. "Enhancing polyelectrolyte strength of biopolymers for fully recyclable and biodegradable plastics," *ACS Applied Materials & Interfaces*, 17(28), 41112-41123, 2025.
2. Q Chen*, **PC Cai***, THW Chang, EB Burgener, MJ Kratochvil, A Gupta, A Hargill, PR Secor, J Nielsen, AE Barron, CE Milla, SC Heilshorn, AJ Spakowitz, and PL Bollyky. "Pf bacteriophages hinder sputum antibiotic diffusion via electrostatic binding," in *Science Advances*, 10: eadl5576, 2024.
3. **PC Cai***, M Braunreuther*, A Shih, AJ Spakowitz, SC Heilshorn, and GG Fuller. "Air-liquid intestinal cell culture allows *in situ* rheological characterization of intestinal mucus," in *APL Bioengineering*, 8, 026112, 2024.
4. **PC Cai**, B Su, L Zou, MJ Webber, SC Heilshorn, and AJ Spakowitz. "Rheological Characterization and Theoretical Modeling Establish Molecular Design Rules for Tailored Dynamically Associating Polymers," in *ACS Central Science*, 8(9), 1318-1327, 2022.
5. **PC Cai**, BA Krajina, MJ Kratochvil, L Zou, A Zhu, EB Burgener, PL Bollyky, CE Milla, MJ Webber, AJ Spakowitz, and SC Heilshorn. "Dynamic light scattering microrheology for soft and living materials," in *Soft Matter*, 17: 1929-1939, 2021.
6. **PC Cai**, BA Krajina, AJ Spakowitz. "Brachiation of a polymer chain in the presence of a dynamic network," in *Physical Review E*, 102, 020501(R), 2020.

Selected Presentations (5 of 26)

1. "Pf bacteriophages hinder sputum antibiotic diffusion via electrostatic binding," *APS Global Physics Summit*. Anaheim, CA. 2025. ***DBIO Early Career Award Session Selected Speaker***.
2. "Linking molecular structure to macroscopic rheology of dynamically associating polymer networks," *APS March Meeting*. Las Vegas, NV. 2023. ***Padden Award for Excellence in Polymer Physics Research Winner***.
3. "Molecular-Level Theory for Rational Design of Dynamic Polymer Networks," *AIChE Annual Meeting*. Phoenix, AZ. 2022. ***1st Place Speaker Award Winner***.
4. "Leveraging Polymer Physics to Reduce Respiratory Secretions in Severe Cases of SARS-CoV-2 (COVID-19) Infection," *Biophysical Society Annual Meeting*. San Francisco, CA. 2022. ***Best Speaker Award Winner***.
5. "Biophysical Characterization of Respiratory Secretions in Severe SARS-CoV-2 (COVID-19) Infections," *10th Annual MIT Polymer Day*. Virtual. 2021. ***1st Place Poster Award Winner***.

Selected Honors & Awards

Arnold O. Beckman Postdoctoral Fellowship, Arnold & Mabel Beckman Foundation	2024–2025
Global Outstanding Student Award in PMSE, ACS	2024
Director's Discretionary Allocation Grant, Argonne Leadership Computing Facility (ALCF)	2023–2024
Frank J. Padden, Jr. Award for Excellence in Polymer Physics Research, American Physical Society (APS)	2023
MIT Rising Star in Chemical Engineering	2022
Stanford Bio-X Honorary Fellow	2019–2022
National Science Foundation (NSF) Graduate Research Fellowship (GRFP)	2019–2022
Robert T. Haslam Cup for showing most promise as a future chemical engineer, MIT	2016

Selected Mentorship & Outreach

Math Tutor at Wendell Phillips High School, *Chicago, IL*	2023–2024
Vice President, Stanford Polymer Collective (SPC), *Stanford, CA*	2022–2023
Room Leader for Stanford Future Advancers of Science and Technology (FAST), *San Jose, CA*	2019–2023

Hobbies

running, playing violin and piano, baking, hiking, reading