

## **Liheng Cai**

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- Education**
- University of North Carolina**, Chapel Hill, 2012  
Ph.D. in Materials Science  
Thesis title: Structure and Function of Airway Surface Layer of the Human Lungs & Mobility of Probe Particles in Complex Fluids  
Advisor: Prof. Michael Rubinstein
  - Lanzhou University**, China, 2006  
B.S. in Physics (with highest honor)
- Research and activities**
- University of Virginia**, Charlottesville, VA (01/2018- )  
Assistant Professor, Department Materials Science and Engineering  
Assistant Professor, Department of Chemical Engineering  
Assistant Professor (by courtesy), Department of Biomedical Engineering
  - Harvard University**, Cambridge, MA (04/2013 – 12/2017)  
*Postdoctoral Fellow* with Prof. David A. Weitz and Prof. Jeffrey Fredberg  
Researched in polymer synthesis, characterization, and theory – created soft, tough, self-healing yet ‘dry’ polymers.  
Researched in droplet microfluidics for materials production and single-cell encapsulation and screening.  
Researched in collective cell migration and human airway remodeling.
  - University of North Carolina**, Chapel Hill (05/2012 – 04/2013)  
*Postdoctoral Researcher* with Prof. Michael Rubinstein and Prof. Richard C. Boucher  
Built up an experimental biophysics laboratory from scratch.
  - University of North Carolina**, Chapel Hill (08/2007 – 05/2012)  
*Research Assistant* with Prof. Michael Rubinstein and Prof. Richard C. Boucher  
Developed scaling theories for diffusion of nanoparticles in complex fluids and for self-healing polymers.  
Discovered “Gel-on-Brush” model for mucus clearance of human airway.
  - Lanzhou University, China (06/2004 – 08/2007)**  
*Research Assistant* with Prof. Fashen Li and Prof. Desheng Xue  
Synthesized magnetic nano-arrays for data storage with Prof. Fashen Li.  
Researched in numerical simulation of inverse problems with Desheng Xue under support from Hui-Chun Chin and Tsung-Dao Lee Chinese Undergraduate Research Endowment.
- Honors and Awards**
- 2015, Travel award, Gordon Research Conference: Cilia, Mucus & Mucociliary Interactions
  - 2014, Best poster award, Gordon Research Conference: Antibody Biology & Engineering
  - 2014, Harvard University Postdoctoral Award for Professional Development
  - 2013, North Carolina Impact Award
  - 2012, Boulder Soft Condensed Matter Summer School
  - 2012, Best poster award, Visiting Pulmonary Scholar Program Series
  - 2011, Fellowship, Kavli Institute for Theoretical Physics at Santa Barbara
  - 2004, Chun-Tsung Scholar

**Affiliations** American Physical Society Materials Research Society  
American Chemical Society American Institute of Chemical Engineers (AIChE)  
American Thoracic Society

**Publications** **Articles** (peer reviewed) [\*Equal contribution; +Correspondence]  
**Experimental work**

1. D. Chen, E. Amstad, C. Zhao, **L.-H. Cai**, J. Fan, Q. Chen, M. Hai, S. Koehler, H. Zhang, F. Liang, Z. Yang, D.A. Weitz. Biocompatible amphiphilic hydrogel-solid dimer particles as colloidal surfactants. *ACS Nano* 11, 11978 (2017).
2. J. Wu, **L.-H. Cai**<sup>+</sup>, and D. A. Weitz<sup>+</sup>. Tough self-healing elastomers from molecular enforced integration of covalent and reversible networks. *Advanced Materials* 29, 1702616 (2017). Selected as Cover Article, reported by [Harvard News](#), [EurekaAlert](#), [Fox News](#), [Farsnews](#), [The Guardian](#), [Yahoo!](#), [DailyMail](#), [Phys.org](#), [Digital Trends](#), [Rubber News](#), [The Times of India \(Delhi\)](#), [GlobalSpec](#), [Digital Journal](#), [Engineers Australia](#) etc.
3. W. Xing, H. Li, G. Huang<sup>+</sup>, **L.-H. Cai**<sup>+</sup>, J. Wu<sup>+</sup>. Graphene oxide induced crosslinking and reinforcement of elastomers. *Composites Science and Technology* 144, 223 (2017).
4. Y. Qin, Y. Hu, S. A. Koehler, **L.-H. Cai**, J. Wen, X. Tan, W. L. Xu, Q. Sheng, X. Hou, J. Xue, Ultrafast nanofiltration through large-area single-layered graphene membranes. *ACS Applied Materials & Interfaces* 9, 9239 (2017). W. Xing, H. Li, G. Huang, **L.-H. Cai**<sup>+</sup>, J. Wu<sup>+</sup>. Graphene oxide induced crosslinking and reinforcement of elastomers. *Composites Science and Technology* 144, 223 (2017)
5. L. Zhang\*, **L.-H. Cai**\*, L. S. Philipp, T. Rossow, Q. Vallmajo-Martin, D. Ingmar, M. Ehrbar, H. Na, D. Mooney, and D.A. Weitz. One-step microfluidic fabrication of polyelectrolyte microcapsules in aqueous condition for protein release. *Angewandte Chemie International Edition* 55, 13470 (2016).
6. K. Wang, **L.-H. Cai**, B. Lan, and J. J. Fredberg. Hidden in mist no more: Physical force in cell biology. *Nature Methods* 13, 124 (2016)
7. **L.-H. Cai**\*, T.E. Kodger\*, R.E. Guerra, A.F. Pegoraro, M. Rubinstein, and D.A. Weitz. Soft elastomers from architecture-driven entanglement free design. *Advanced Materials* 27, 5132 (2015). Selected as [Cover Article](#), reported by [Harvard News](#), [Science Daily](#) and etc.
8. A. G. Henderson, C. Ehre, B. Button, L.H. Abdullah, **L.-H. Cai**, M.W. Leigh, G. DeMaria, H. Matsui, S.H. Donaldson, C. W. Davis, J. K. Sheehan, R. C. Boucher, and M. Kesimer. Cystic fibrosis airway secretions exhibit mucin hyperconcentration and increased osmotic pressure. *Journal of Clinical Investigation* 124, 3047 (2014).
9. B. Button\*, **L.-H. Cai**\*, C. Ehre, M. Kesimer, D. B. Hill, J. K. Sheehan, R. C. Boucher, and M. Rubinstein. A periciliary brush promotes the lung health by separating the mucus layer from airway epithelia. *Science* 337, 937 (2012). Selected as [Cover Article](#), highlighted by a [Perspective](#), and reported by [BBC](#), [US News & World Report](#) and etc.
10. D. Zhou, **L.-H. Cai**, F.-S. Wen, and F.-S. Li. Template synthesis and magnetic behavior of FeNi alloy nanotube arrays. *Chinese Journal of Chemical Physics* 20, 821 (2007).

### Theoretical Work

11. **L.-H. Cai**, S. Panyukov, and M. Rubinstein. Hopping diffusion of non-sticky nanoparticles in polymer matrices. *Macromolecules* 48, 847 (2015).
12. E. B. Stukalin\*, **L.-H. Cai\***, N. A. Kumar, L. Leibler, and M. Rubinstein. Self-healing of unentangled polymer networks with reversible bonds. *Macromolecules* 46, 7525 (2013)
13. **L.-H. Cai**, S. Panyukov, and M. Rubinstein. Mobility of nonsticky nanoparticles in polymer liquids. *Macromolecules* 44, 7853 (2011).

### Book Chapters

1. J. Wu, **L.-H. Cai**+, H. Wang, Advanced Materials for Self-Healing Applications. Design, Fabrication, Properties and Applications of Smart and Advanced Materials, 308 (2016).

### Patents

1. D.A Weitz, J. Wu, and **L.-H. Cai**. “Self-healing elastomers.” U.S. Provisional Application No.: 62/533,504
2. **L.-H. Cai**, T. E. Kodger, R. E. Guerra, A. F. Pegoraro, M. Rubinstein, and D.A. Weitz. “Soft elastomers from architecture-driven disentanglement design and its use.” Filed in Feb. 2014.

### Professional Activities

#### Mentoring

**University of Virginia**, 2018 –  
Zihao Gong (G1, MSE)

#### Harvard University, 2013-2017

Yongcheng Wang, 2016-2017 (G3 @ Harvard)

Yinan Shen, 2015-2017 (G3 @ Harvard)

Anqi Chen, 2016-2017 (G2 @ Harvard)

Samuel Lienemann, 2016-2017 (Visiting, G1 @ ETH Zurich)

Beatriz Miranda, 2015-2016 (Visiting, G1 @ Universidade de São Paulo)

Bobby Haney, Summer 2016 (Visiting, G2 @ Florida State University)

Jacqueline Flood, Summer 2014 (REU, Junior @ Harvard)

Vivian Yang, Summer 2014 (Intern, Senior @ National Tsing Hua University, now @ U. Toronto)

#### Teaching

Teaching Assistant at University of North Carolina at Chapel Hill

- *Polymer Physical Chemistry*, taught by Prof. Michael Rubinstein, 20 students, 1 hour/section, 2 sections/week, Fall 2009 – Spring 2010 and Fall 2010 – Spring 2011  
Graded homework, gave lectures when professor is out of town, and designed mid-term and final exam projects.
- *Statistical Thermodynamics of Materials*, 30 students, 1 hour/section, 2 sections/week, Fall 2008 and Fall 2010
- *Analog and Digital Electronics*, 80 students, 1 hour/section, 2 sections/week, Spring 2008
- *General Physics Labs*, 15 students, 2 hour/section, 1 section/week, Fall 2007 and Spring 2008

#### Conference/workshop organizing

2014-2017, Organizer for weekly [Squishy Physics](#) seminar series at Harvard University

Invited and hosted researchers in soft matter, biophysics, materials science, and chemical

engineering from Boston area and scientists visiting to Boston to give Squishy Physics seminars.

2014-2017, Organizer for Biophysics Subgroup meetings in Weitz Lab

2013, Course organizer for Harvard undergraduate class Science & Cooking: From Haute Cuisine to Soft Matter Science, 300 students

2013-2016, Helped organize New England Complex Fluids meetings at Harvard

2008, Helped *initiate* the first Triangle Soft Matter Workshop

#### **Referee Service** (selected)

Nature, PNAS, Scientific Reports, Advanced Materials, Advanced Functional Materials, Advanced Materials Technologies, Macromolecules, ACS Macro Letters, Small, Biophysics Journal, Biomacromolecules, Soft Matter, Materials Horizons, Chemical Communications, Journal of Allergy and Clinical Immunology.

#### **Invited and other talks**

##### **Invited talks**

###### **2018**

*Title: "Human airway epithelial responses to chronic pathological osmotic stress"*

02/24: Marsico Lung Institute, School of Medicine, University of North Carolina, Chapel Hill

###### **2017**

*Title: "Polymer science as a tool for materials design and biological discoveries"*

11/08: Institute of Physics, Chinese Academy of Science, Beijing

11/07: Department of Chemistry, Peking University, Beijing

11/06: Institute of Chemistry, Chinese Academy of Science, Beijing

11/03: Department of Chemical Engineering, Tsinghua University, Beijing

*Title: "Biomimetic materials by design: Soft, tough, self-healing dry elastomers"*

University of Pennsylvania, Department of Materials Science and Engineering

University of Virginia, Departments of Chemical Engineering and Materials Science and Engineering

University of Virginia, Department of Biomedical Engineering

Syracuse U, Department of Biomolecular and Chemical Engineering

Case Western Reserve University, Department of Macromolecular Science and Engineering

Auburn University, Chemical Engineering

*Title: "Soft matter approaches to biology: A tale of mucus hydrogel in human lung defense"*

Virginia Tech, Department of Physics

Syracuse U, Department of Physics

###### **Before 2017**

*Title: "Soft functional materials from molecular design"*

2016/05: University of Massachusetts at Amherst, Polymer Science and Engineering Department.

2015/08: University of North Carolina at Chapel Hill, Department of Chemistry.

*Title: "Interaction between mucus and cilia in health and disease"*

2015/09: Harvard University, School of Public Health.

2014/06: International Young Scholars Systems and Synthetic Biology Symposium. Beijing, China

2013/07: 7<sup>th</sup> International Discussion Meeting on Relaxation in Complex Systems (IDMRCS). Spain.

2013/05: Harvard University, Squishy Physics Seminar Series.

2013/05: Harvard University, Wyss Institute for Biologically Inspired Engineering.

2011/02: Gordon Research Conferences: Cilia, Mucus & Mucociliary Interactions, Ventura, CA.

*Title: "Permeability of polyelectrolyte microcapsules"*

2015/10: Harvard University, Kavli Seminar Series.

*Title: "Droplet-based microfluidic platform for high-throughput screening of antibody producing cells"*  
2014/03: Gordon Research Seminar: Antibody Biology & Engineering. Lucca (Barga), Italy.

**Contributed talks** (selected)

**Polymer science**

*Title: "Tough self-healing elastomers from molecular enforced integration of covalent and reversible bonds"*

2018/03: APS March Meeting. Los Angeles, CA  
2016/07: Gordon Research Conference: Polymer Physics. South Hadley, MA  
2015/08: Gordon Research Conference: Soft Condensed Matter Physics. New London, NH  
2015/06: International Conference on Self-Healing Materials. Durham, NC

*Title: "Ultra-soft yet dry elastomers from architecture-driven entanglement free design"*

2016/11: AIChE Annual Meeting. San Francisco, CA  
2015/12: Materials Research Society (MRS) Fall Meeting & Exhibit. Boston, MA

**Mucus hydrogels**

*Title: "Human airway brush keeps the lung healthy"*

2014/03: American Physical Society March Meeting. Denver, CO  
2012/03: 2<sup>nd</sup> Visiting Pulmonary Scholar Program. Chapel Hill, NC  
2012/03: American Physical Society March Meeting. Boston, MA  
2011/05: Soft Matter Physics Approaches to Biology. Santa Barbara, CA

*Title: "Roles of mucus adhesion and cohesion in health and disease"*

2012/10: 26th Annual North American Cystic Fibrosis Conference. Orlando, FL

*Title: "Osmotic pressure of endogenous mucus reveals robustness of human airway defense"*

2015/03: Gordon Research Conferences: Cilia, Mucus & Mucociliary Interactions, Galveston, TX

**Transport of particles in complex fluids**

*Title: "Hopping diffusion of nanoparticles in polymer networks and gels"*

2013/03: American Physical Society March Meeting. Baltimore, MD

*Title: "Mobility of nanoparticles in complex fluids"*

2011/03: American Physical Society March Meeting. Dallas, TX  
2010/06: Gordon Research Conferences: Polymer Physics. South Hadley, MA  
2010/03: American Physical Society March Meeting 2010. Portland, OR

**Microfluidics**

*Title: "Single emulsion-templated fabrication of amphiphilic Janus particles for stabilizing mini-emulsions"*

2016/08: 90<sup>th</sup> ACS Colloid & Surface Science Symposium. Cambridge, MA