



## Nano-engineering Soft Materials for Unprecedented Properties

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Soft materials emerging on the interface between engineering and biological systems are challenging our fundamental knowledge, inspiring technological innovations, and enabling impactful applications. For instance, mammalian muscles, tendons and cartilages, albeit containing ~70% water and having a wide range of rigidity (i.e., 100kPa~10MPa), can maintain impressively high fracture toughness (i.e.,  $>1000 \text{ Jm}^{-2}$ ) under millions of cycles of loads. Marine mussels and barnacles secrete soft glues to form robust adhesions (i.e.,  $>100 \text{ Jm}^{-2}$ ) to rocks and metals in flowing water with high salinity. Camouflage animals such as cephalopods can dynamically vary hierarchical textures and colors of their skins within seconds to blend in diverse environments.

At MIT SAMs Lab, we integrate theory and experiments to understand the physics and mechanics of these intriguing biological materials and phenomena, and seek bio-inspirations to design new soft materials to achieve extraordinary properties. We propose that judicious designs of unconventional polymer networks such as interpenetrating networks, multimodal chain distributions, hybrid crosslinkings, and transformable domains at nano-scales represent a general strategy to achieve soft materials with extraordinary properties. Guided by this strategy and theoretical models, I will demonstrate examples of our recent designs including: (1) a set of new soft materials with similar water contents and moduli as muscles, tendons and cartilages but much higher fracture toughness (i.e.,  $>10,000 \text{ Jm}^{-2}$ ) and anti-fatigue properties; (2) new underwater soft glues that bond to diverse solids including glass, ceramics, silicon, metals and polymers with interfacial toughness (i.e.,  $>1500 \text{ Jm}^{-2}$ ) much higher than their natural counterparts; and (3) new active polymers that can change both topographic textures and colors under the control of programmed voltages. I will conclude this talk by briefly discussing two emerging manufacturing strategies of soft materials: synthetic biology for new biopolymers and nanostructures, and 3D printing for new microstructures.

### Speaker biography:

Xuanhe Zhao received his PhD in Mechanical Engineering from Harvard University. In 2010, Dr. Zhao joined the faculty of Department of Mechanical Engineering and Materials Science, Duke University. In 2014, Dr. Zhao and his group moved to Department of Mechanical Engineering, MIT, where he is now an associate professor. Dr. Zhao's current research goal is to understand and design soft materials that possess unprecedented properties and functions. Dr. Zhao is a recipient of the NSF CAREER Award, the ONR Young Investigator Award, and the Early Career Researchers Award from AVS Biomaterial Interfaces Division. He was the Hunt Faculty Scholar at Duke and d'Arbeloff Career Development Chair and Robert N. Noyce Career Development Professor at MIT.

#### *Time/Date:*

22 October 2015  
1400-1500

#### *Location:*

ISN Seminar Room  
500 Technology Square, Room 189  
(NE47-189)  
Cambridge, MA 02139

#### *Screen-share connection information:*

<https://isn.adobeconnect.com/zhao>

#### *Teleconference line:*

617-324-0000  
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