Massachusetts Institute of Technology
Department of Mechanical Engineering

MMEC SEMINAR SERIES

Mechanics: Modelling, Experimentation, Computation

Tuesdays @ 4:00pm – Room 3-370

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Multi-scale Multi-mechanism Design of Tough and Bioactive Hydrogels: Theory, Experiment and Application

Materials and phenomena emerging on the interface between engineering and biological systems are constantly challenging our fundamental knowledge, inspiring technological innovations, and enabling impactful applications. For instance, mammalian skeletal muscles can achieve actuation stress and strain up to 400 kPa and 40%, with energy efficiency over 70%. Animal skins and plant leaves can develop hierarchical topographical patterns which lead to extraordinary functions such as camouflage and superhydrophobicity. Cartilage, a natural hydrogel that contains ~70% water, can maintain impressively high fracture toughness (i.e., >1000 Jm-2) under millions of cycles of loads equivalent to body weights. At Duke SAMs Lab, we integrate theoretical and experimental tools to understand the physics and mechanics of these intriguing biological materials and phenomena, and seek bio-inspirations to develop new multifunctional materials and structures such as artificial muscle, transformative skin, and tough cartilage.

In this talk, I will focus on our recent work on the design of tough and bioactive hydrogels. Injury and disease of load-bearing tissues such as articular cartilages and spine disks have huge impacts on both millions of peoples' wellbeing and a multi-billion-dollar biomaterial industry, posing critical healthcare challenge to our aging society. Since most synthetic hydrogels are mechanically weak and brittle, current replacements for injured or diseased load-bearing tissues have to rely on metals and rigid plastics, sacrificing hydrogels' bioactivity and flexibility for mechanical robustness. Inspired by the mechanics and structures of tough biological tissues, we propose that a general principle for the design of tough hydrogels is to implement two mechanisms for dissipating mechanical energy and maintaining high elasticity in hydrogels.
A particularly promising strategy for the design is to integrate multiple pairs of mechanisms across multiple length scales into a hydrogel. Guided by our theoretical model and design principle, we develop a new hydrogel system with extremely high toughness (> 20 kJm-2) as well as capability of stem-cell encapsulation. Applications of the tough and bioactive hydrogels will be further discussed, for example, by 3D printing them into various prototypes for tissue regeneration.

Seminar Host: Ken Kamrin (kkamrin@mit.edu)

Please join us for ***refreshments beforehand, outside Room 3-370***

For more information, visit our website at http://web.mit.edu/mmec/
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