How Protein Gels Stiffen, Harden and Remember

Daniel Blair*

Georgetown University, Department of Physics and Institute for Soft Matter Synthesis and Metrology

The material properties of solids can be strongly coupled to the magnitude of externally applied shear deformations. Yield, flow and plasticity are terms used to describe the irreversible mechanical alterations to highly deformed matter. Soft disordered solids composed of discrete elements have relatively small yield strains that is closely linked to the length scale and interaction energies of the constituents. In contrast however, many biopolymer gels can respond in in ways that are distinct from their synthetic analogs. In particular, biological gels exhibit remarkable nonlinear elasticities resulting in dramatic increases in material stiffness[1]. In this talk I will discuss our results that connect the structure and mechanics for a variety of biologically derived gel networks including intra- and extra- cellular matrices and reconstituted silks [2–5]. All of these materials exhibit a highly nonlinear response that is linked to the existence of hierarchical structures and complex cross-linking. Overall, the resulting nonlinear rheology is a mix of hardening, stiffening and mechano-memory effects under the application of large shear strains. I will connect these bulk viscoelastic descriptions to the microscopic behavior of the gels through real space 3-D imaging, boundary stress microscopy, and neutron scattering. If there is time, I will also discuss recent results on the mechanics of active gel networks.

* Corresponding author: daniel.blair@georgetown.edu

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