Abstract Submitted
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Nonlinear Elasticity of Biological and Polymeric Networks and Gels[1] A.J. OYER, J.-M.Y. CARRILLO, A.V. DOBRYNIN, University of Connecticut, F.C. MACKINTOSH, Vrije Universiteit — Biological and polymeric networks show remarkably high deformability at relatively small stresses and can sustain reversible deformations up to ten times of their initial size. Using theoretical analysis and molecular dynamics simulations we propose and test a theory that describes nonlinear mechanical properties of a broad variety of biological and polymeric networks and gels by relating their macroscopic strain-hardening behavior with molecular parameters of the network strands. This theory provides a universal relationship between the strain-dependent network modulus and the network deformation as a function of the first invariant, I_1, of the network deformation matrix. Our analysis shows that depending on the rigidity of the polymeric strands between cross-links there are two different nonlinear network deformation regimes. Networks made of polymer chains with bending constant $K>1$ behave as polymeric network made of a worm-like chains in the interval of network deformations $\frac{\beta I_1}{3} < 1 - \left(K^2+2\right)^{-1/2}$ and as networks made of freely-jointed chains for $\frac{\beta I_1}{3} > 1 - \left(K^2+2\right)^{-1/2}$ ($\beta \approx \langle R_{in}^2 \rangle / R_{\max}^2$ is a strand extensibility ratio of the mean-square value of the undeformed strand size, $\langle R_{in}^2 \rangle$, to the square of the fully extended strand size, $R_{\max}^2$. However, networks made of flexible chains with $K<<1$ have only one nonlinear deformation regime.

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