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Compression of fibrin networks modeled as a foam

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ABSTRACT

Fibrin networks are important components of extracellular proteinaceous gels that are widely used in biological experiments as well as medical applications. They are also the key components of blood clots. Although the tensile and shear behavior of these gels is relatively well-understood, the compression response is not. We show here that the compression behavior of fibrin networks is very similar to the compression response of cellular solids. There is an initial linear regime in which most fibers are straight. This is followed by a plateau regime in which more and more fibers buckle, whereas the stress remains nearly constant as strain increases. Finally, there is densified region in which the stress–strain response is markedly nonlinear and dominated by fiber bending. The straight and densified regimes can be treated as two phases of a foam consisting of fibers with known constitutive relations. The plateau regime consists of a mixture of these two phases. The parallel plate viscometer experiments which are used to probe the storage and loss moduli cause a change in the fractions of each phase in the plateau regime. We describe this using a continuum theory of phase transitions. We are able to calculate the storage and loss moduli analytically and show that our results agree with the experiments.