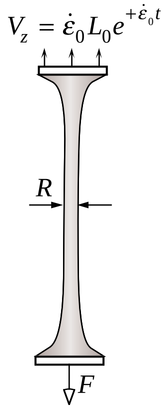

FIG. 1

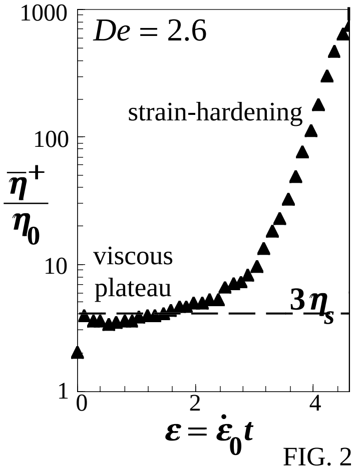

FIG. 2

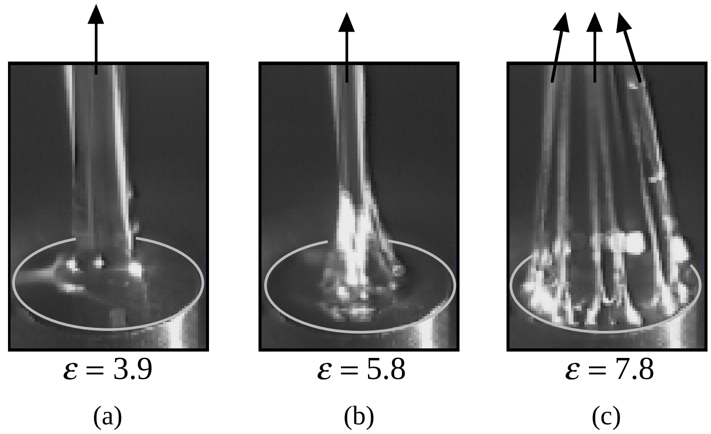

FIG. 3

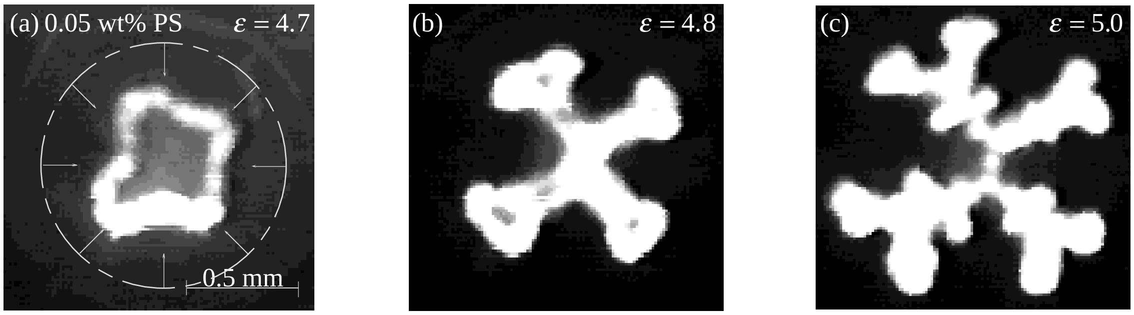

FIG. 4

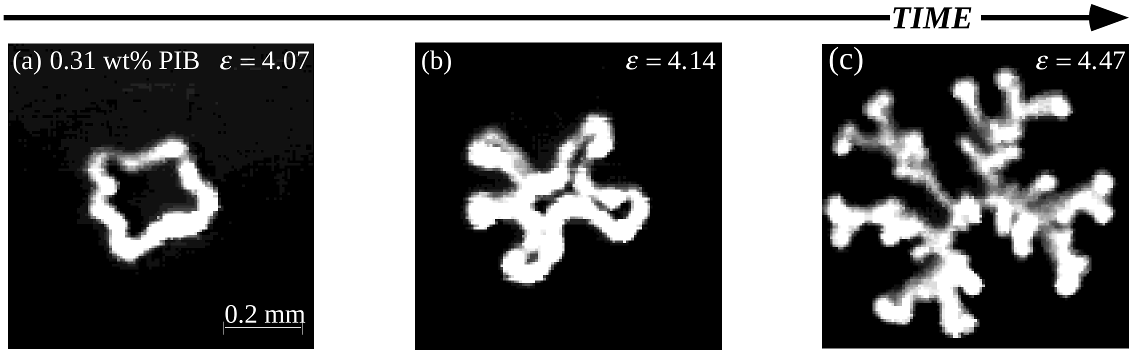

FIG. 5

ELASTIC INSTABILITY IN ELONGATING FLUID FILAMENTS

Submitted by Shelley L. Anna, Stephen H. Spiegelberg, and Gareth H. McKinley
(Division of Engineering and Applied Sciences, Harvard University)

To quantify the response of dilute polymer solutions in strong extensional flows, we measure the transient extensional viscosity by exponentially elongating cylindrical fluid filaments as indicated in Fig. 1. Measurement of the filament radius *R(t)* and the tensile force *F(t)* exerted on the endplate (corrected for surface tension σ) leads to the definition of a Trouton ratio $Tr = \bar{\eta}^+/\eta_0 = F/(\pi R^2 \dot{\varepsilon}_0) - \sigma/\dot{\varepsilon}_0 R$.[1] Ideal elastic polymer solutions (or "Boger fluids") exhibit pronounced strain hardening and Trouton ratios, $Tr \approx O(10^3)$ in uniaxial elongation as shown in Fig. 2. At high strains, this rapid tensile stress growth leads to an unexpected elastic free-surface instability.[2] The cylindrical fluid filament loses axisymmetry and an azimuthally-periodic series of thin elastic fibrils evolve near the stationary endplate as shown in Fig 3. As the strain and tensile stress increase, the filament can ultimately separate entirely from the rigid endplate. By using a glass endplate, plan views of the evolution in spatial structure of the instability are obtained as shown in Figs. 4 and 5. The disturbance at the radially-contracting free surface of the filament is initially periodic and characterized by an azimuthal mode number that varies with fluid composition, Deborah number and strain. As the straining continues, thin finger-like lobes form which grow *radially outward*, tip-splitting and branching in a familiar fractal-like pattern. This elastically-driven instability is cohesive rather than adhesive in nature and can be characterized as a modified Taylor meniscus instability[3] in which destabilizing elastic normal stresses in the bulk of the fluid compete with the stabilizing interfacial tension of the curved free surface.

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