Supplemental Information:

A 2D model fit is utilized to determine the diameter of the partially oriented fibers as a function of strain. Here, the absolute intensity, I(**q**), at each detector pixel is fit with the 2D cylinder form factor, $P(\mathbf{q})$ (Equation 3) using SansView:[1, 2]

$$I(\mathbf{q}) = \Phi \pi r^2 L (\Delta\rho)^2 P(\mathbf{q}) + bkg \qquad \text{Equation 3}$$

where **q** is the scattering vector, Φ is the volume fraction of fibers, r and L are the radius and length of the fibers respectively, $\Delta\rho$ is the scattering length density contrast term and *bkg* is the incoherent background.

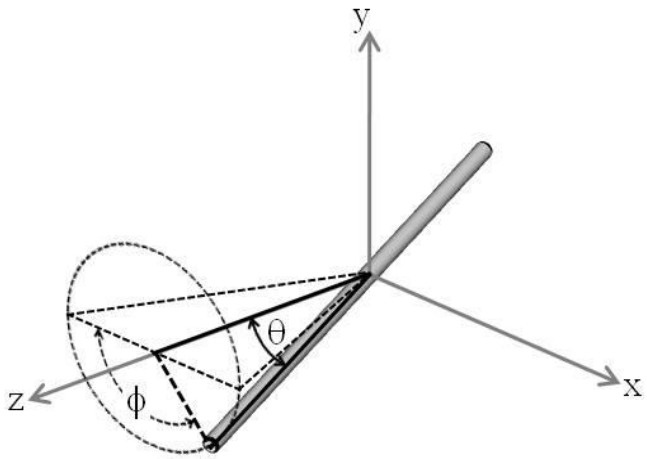

Figure S-1: Definition of the angles ϕ and θ of the oriented cylinder with respect to the incident beam (z-axis) and the detector plane (x-y plane).

The generalized form factor for a distribution of oriented cylinders is defined by Equation S-1:

$$P(\mathbf{q}) = \int_0^{2\pi} d\phi \int_0^{\pi} p(\theta,\phi) P_0(\mathbf{q},\alpha) \sin\theta d\theta \qquad \text{Equation S-1}$$

where $p(\theta,\phi)$ is the probability distribution for the orientation of the fiber over which the cylinder form factor, $P_0(\mathbf{q},\alpha)$, is averaged. The probability distribution for the orientation of the

fibers is defined in terms of ϕ, the orientation distribution in a plane parallel to the detector, and θ, the orientation distribution relative to the incident beam as illustrated in Figures S-1. Because the direction of deformation is parallel to the detector plane, the fibers orient themselves solely with respect to ϕ, such that $p(\theta,\phi)$ is defined by the orientation distribution function, $F(q,\phi)$, from Equation 1 in the text. The orientation of the fibers with respect to θ is assumed to be fully isotropic, such that a rectangular distribution, describing a uniform probability for fiber orientation over all angles, is utilized. The form factor, $P_0(\mathbf{q},\alpha)$, of fully oriented cylinders is defined by Equation S-2:[3]

$$P_0(q,\alpha) = \left(\frac{2\sin\left(\mathbf{q}L\cos\alpha/2\right)}{\mathbf{q}L\cos\alpha/2} \frac{J_1(\mathbf{q}r\sin\alpha)}{\mathbf{q}r\sin\alpha} \right)^2 \qquad \text{Equation S-2}$$

where α is the angle between the fiber axis and the scattering vector **q**, and J_1 is a first order Bessel function.

Most of the parameters in these equations can be explicitly defined and held fixed so that only the radius and the scattering length density of the fiber are varied as the model is fit to the data. The scattering length density of the deuterated buffer is calculated based on its density and composition and found to be 6.3×10^{-6} Å^{-2}. From our previous study we also know that fibers are only ~19% protein by volume in a 10 mg/mL fibrin gel.[4] The scattering length density of fibrinogen is 3.17×10^{-6} Å^{-2}, so it follows that the scattering length density of the unstrained fiber is 5.7×10^{-6} Å^{-2}. The scattering length density of the fibers is allowed to vary over a narrow range from 5.65×10^{-6} to 5.75×10^{-6} Å^{-2} to account for small shifts in the scattering intensity that may result from changes in the fiber composition (e.g. fiber dehydration) during deformation.

The volume fraction of fibers in the gel is calculated based on the total protein concentration in the sample (10 mg/mL) and the composition of the fiber.[3] The volume fraction of fibers is found to be 0.037 and is held fixed for all fits. The incoherent scattering background is dependent only on sample composition (not morphology) and is therefore invariable as a function of strain. The background is determined from the flat high-q scattering and is found to be 0.3 cm^{-1}. The mean fiber length is fixed to a large value for all fits (15,000 Å), which is much larger than the maximum length that can be resolved with this instrument configuration. Therefore, this parameter does not significantly affect the scattering model in this q-region and any variation as a function of strain is indeterminable. Polydispersity factors are also used in fitting to account for the size distributions in fiber radii and length that are expected to occur in the clot. The distribution is defined by a Gaussian function where the polydispersity factor is simply the ratio of one standard deviation to the mean radius. The polydispersity factors for radius and length are held fixed at 0.4 for all fits.

References:

1. http://danse.chem.utk.edu/sansview.html.
2. A. Guinier, G. Fournet, C. B. Walker and G. H. Vineyard, *Physics Today*, 1956, **9**, 38-39.
3. K. M. Weigandt, D. C. Pozzo and L. Porcar, *Soft Matter*, 2009, **5**, 4321-4330.