Prediction of tissue rupture from percolation of local strain heterogeneities for diagnostics

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Supplementary Note

Extruded collagen fibers

A MP4-movie of the tensile test is included as supplementary file.

Linear fitting of Figure 1 resulted in a Young's modulus of 8.19 ± 0.37 MPa ($R^2 > 0.41$) in low strain region up to 10% strain. Due to the sinusoidal increase of the mechanical deflection by means of a fine screw on the ZwickRoell testing machine, the behaviour of the original strains is not strictly linear, which is reflected in the DIC. A strain of 1% corresponds to a deflection of 20 µm.

Horse aorta

A MP4-movie of the tensile test is included as supplementary file.

The stress-strain curve resulting from a tensile test shows a largely linear behaviour up to the rupture point (see Figure 2) with a Young's modulus of 0.291 ± 0.1 MPa ($R^2 > 0.99$). The imaging of the horse aorta surface in parallel with the stress-strain experiment provided a set of images for DIC. The percolating cluster size shows a minimum at $\approx 12.1\%$, which indicates a concentration of local strain is at a maximum here (see Figure 3). Plastic behaviour may occur from this point onwards; the stretching process is supposed to be irreversible.

Fibril network model

A MP4-movie of the stress-coded fibril model is included as supplementary file.

Supplementary Figures

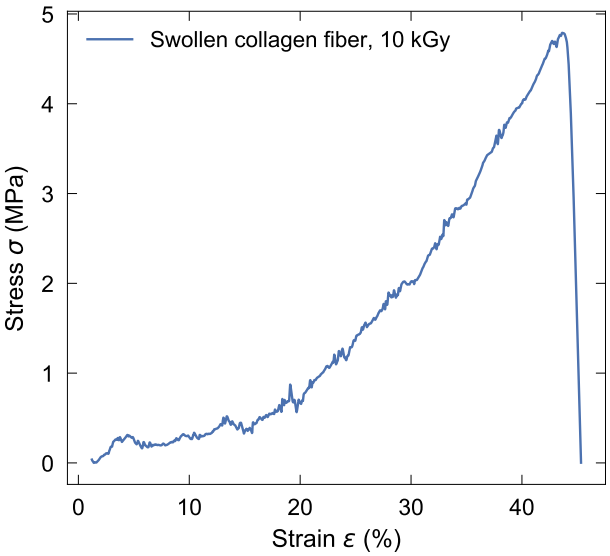

Fig. 1 Stress-strain curve from tensile testing of a energetic electron crosslinked hydrated (swollen) collagen fiber (electron dose: 10 kGy, diameter 200 μm). The force offset due to the experimental setup was removed manually.

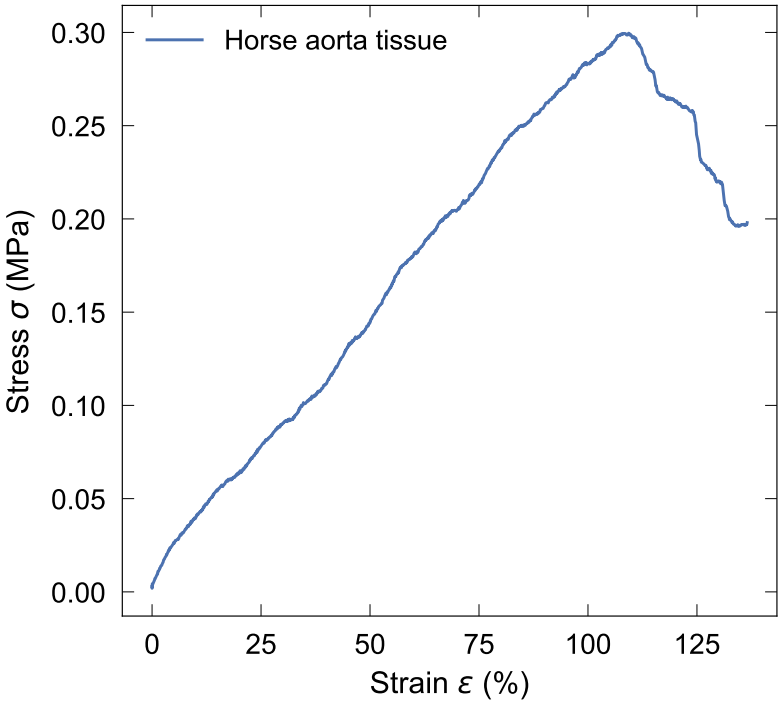

Fig. 2 Stress-strain curve of a horse aorta explant until rupture.

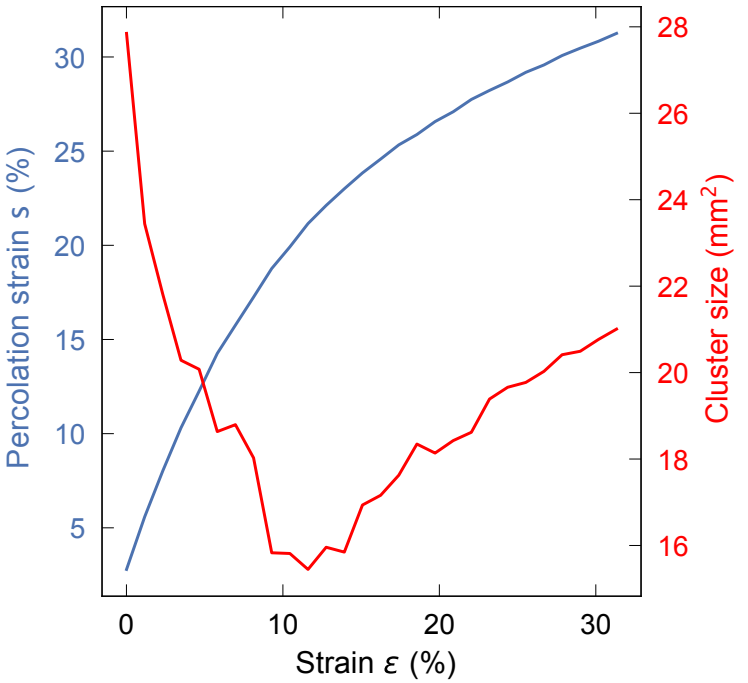

Fig. 3 Percolation strain, s, and size of the percolation cluster for increasing global strains, ϵ, as determined upon evaluation of tensile stretching behavior of a horse aorta explant.

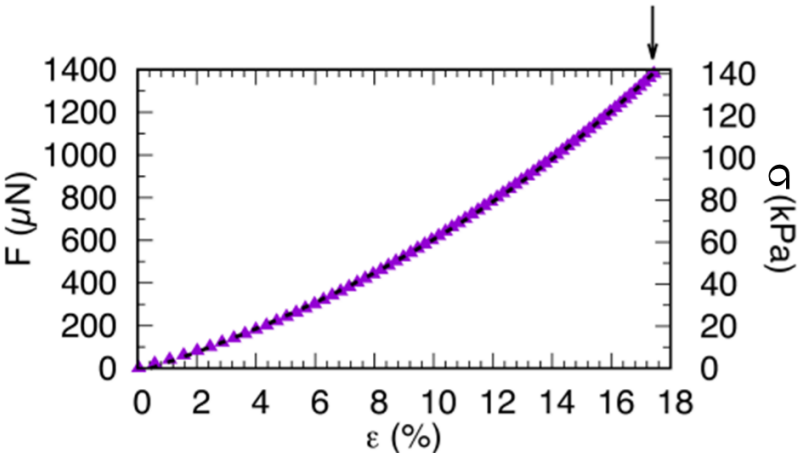

Fig. 4 Green-Lagrange strain vs. force / First Piola Kirchhoff stress σ curve, as predicted by FEM calculations - together with an exponential fit to the data (dashed line). The arrow indicates the strain level that is exemplary discussed in more detail.

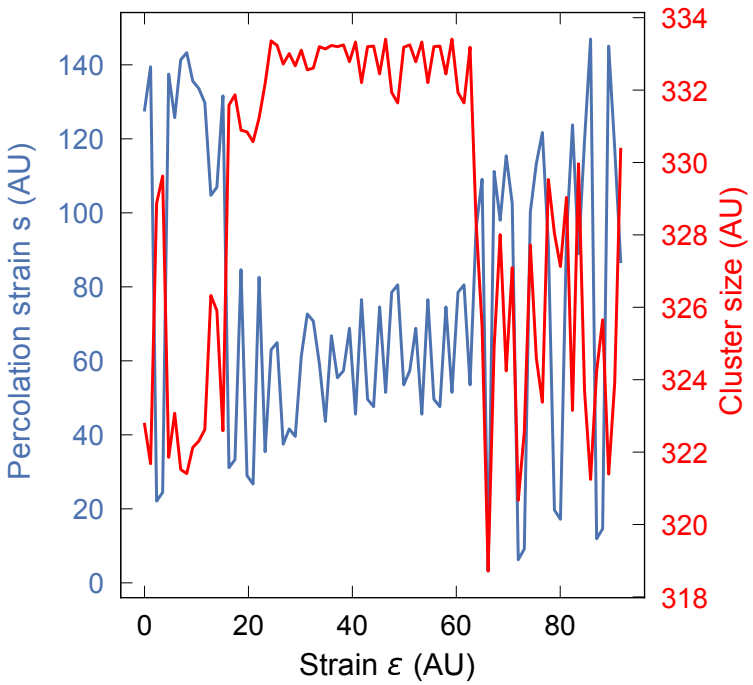

Fig. 5 Percolation strain, s, and size of percolating cluster (measured in arbitrary units, AU), as function of global strain ϵ, for the fibril network model.