Electronic Supplementary Material (ESI) for Soft Matter.

Supporting Information for:

Multilayer Tubes that Constrict, Dilate, and Curl in Response to Stimuli

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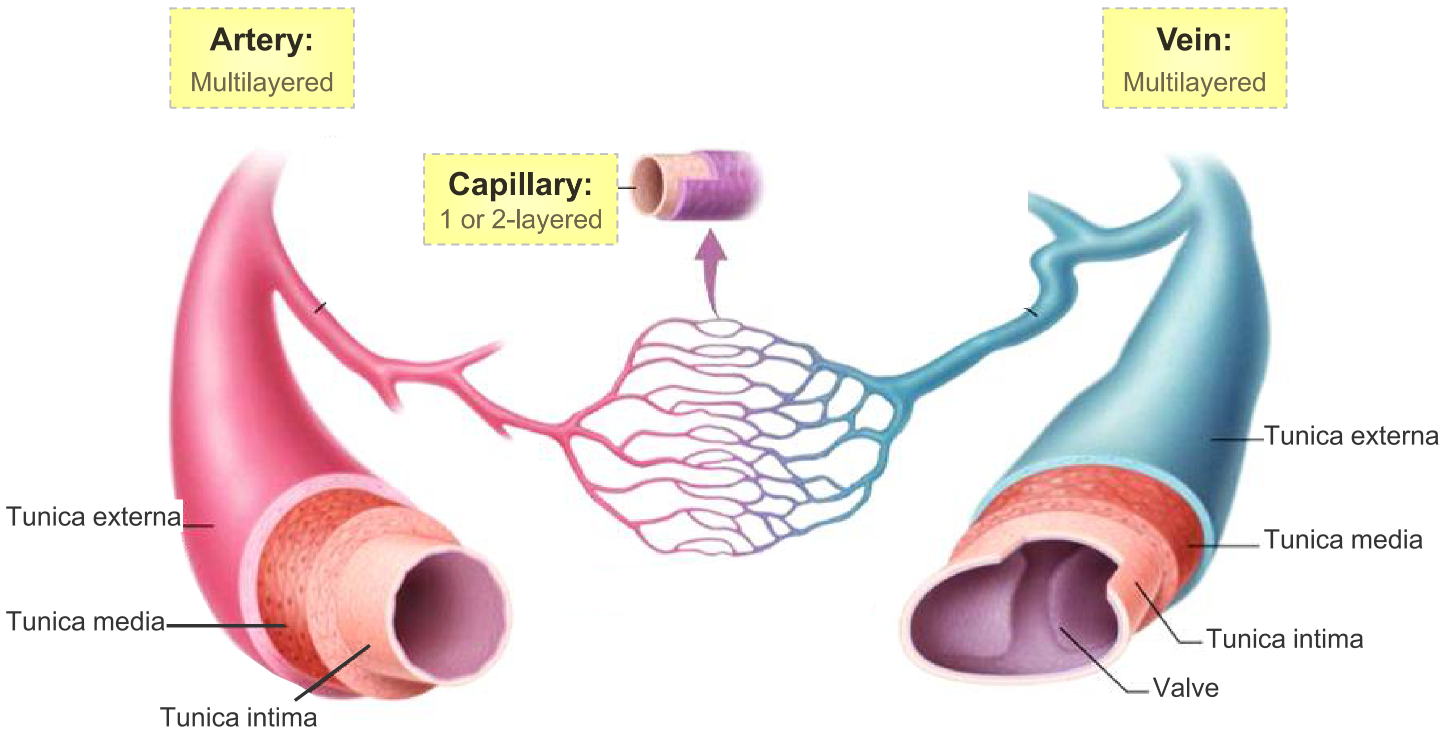

Figure S1. Anatomy of blood vessels. The veins and arteries have the largest inner diameters (up to 30 mm) and these taper off into venules and arterioles, which then further taper off into capillaries (with diameters as small as 8 µm). The capillaries have thin walls with one or two layers. The veins and arteries have thick walls composed of multiple concentric layers, including an innermost layer (*tunica intima*) of endothelial cells, a middle layer (*tunica media*) of smooth muscle tissue, and an outer layer (*tunica externa*) of connective tissue.

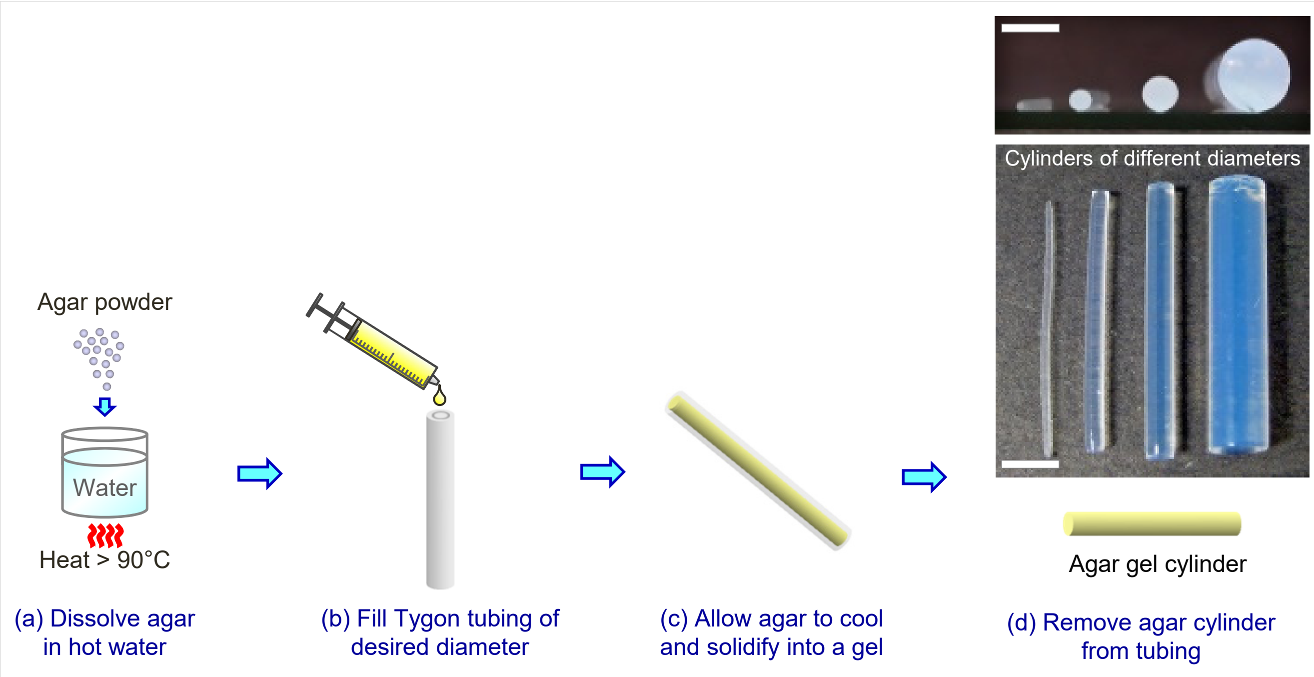

Figure S2. Preparation of agar gel cylinders. (a) Agar is dissolved in hot water. (b) The hot agar solution is poured into a piece of Tygon tubing of desired length and diameter. (c) Upon cooling, an agar gel is formed in the tube. (d) The cylindrical gel is removed from the tube by injecting water into one end of the tube. This cylinder is used as the template for the synthesis shown in Figure 1. The top panels in (d) show agar cylinders of various diameters in top and front views, and the scale bars in the images are 4 mm.

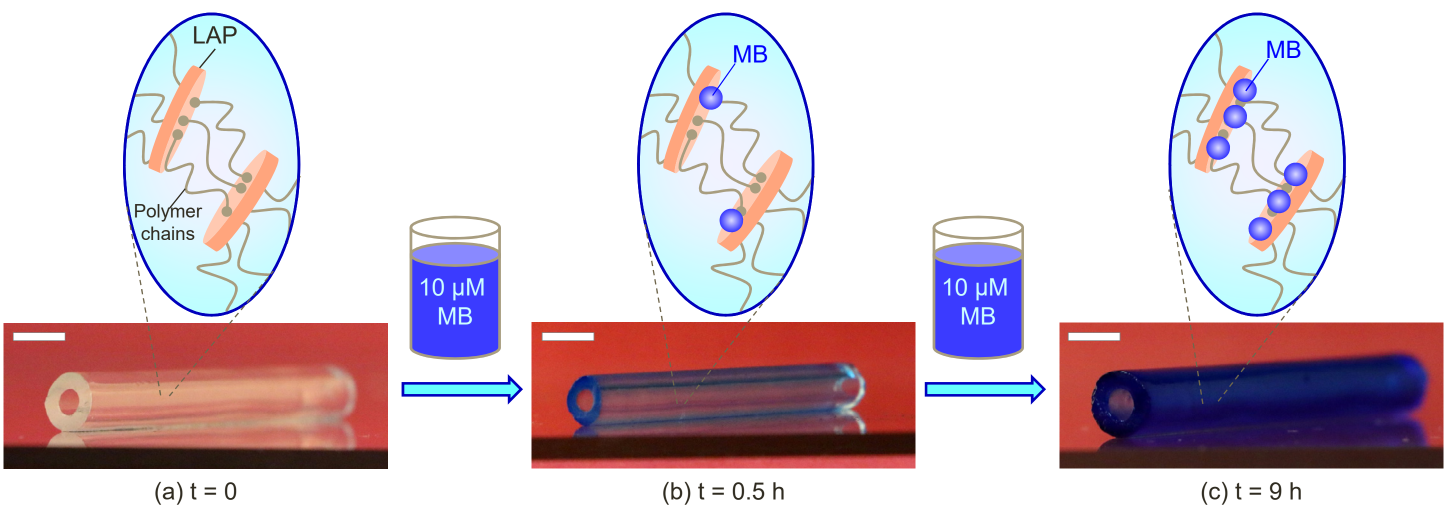

Figure S3. Tube with a polymer layer crosslinked by laponite (LAP) nanoparticles and staining of this layer. LAP particles serve as crosslinkers for growing polymer chains, leading to a polymer network, as shown by the schematics. A tube with a layer of DMAA-LAP is transparent (a). When placed in a 10 µM solution of the cationic dye, methylene blue (MB) for 30 min, the tube wall takes on a light-blue color (b). Incubation in the same MB solution for 9 h gives it a dark blue color (c). The color is due to irreversible adsorption of the MB on the anionic faces of the LAP particles, as shown by the schematics. Scale bars in the images are 4 mm.

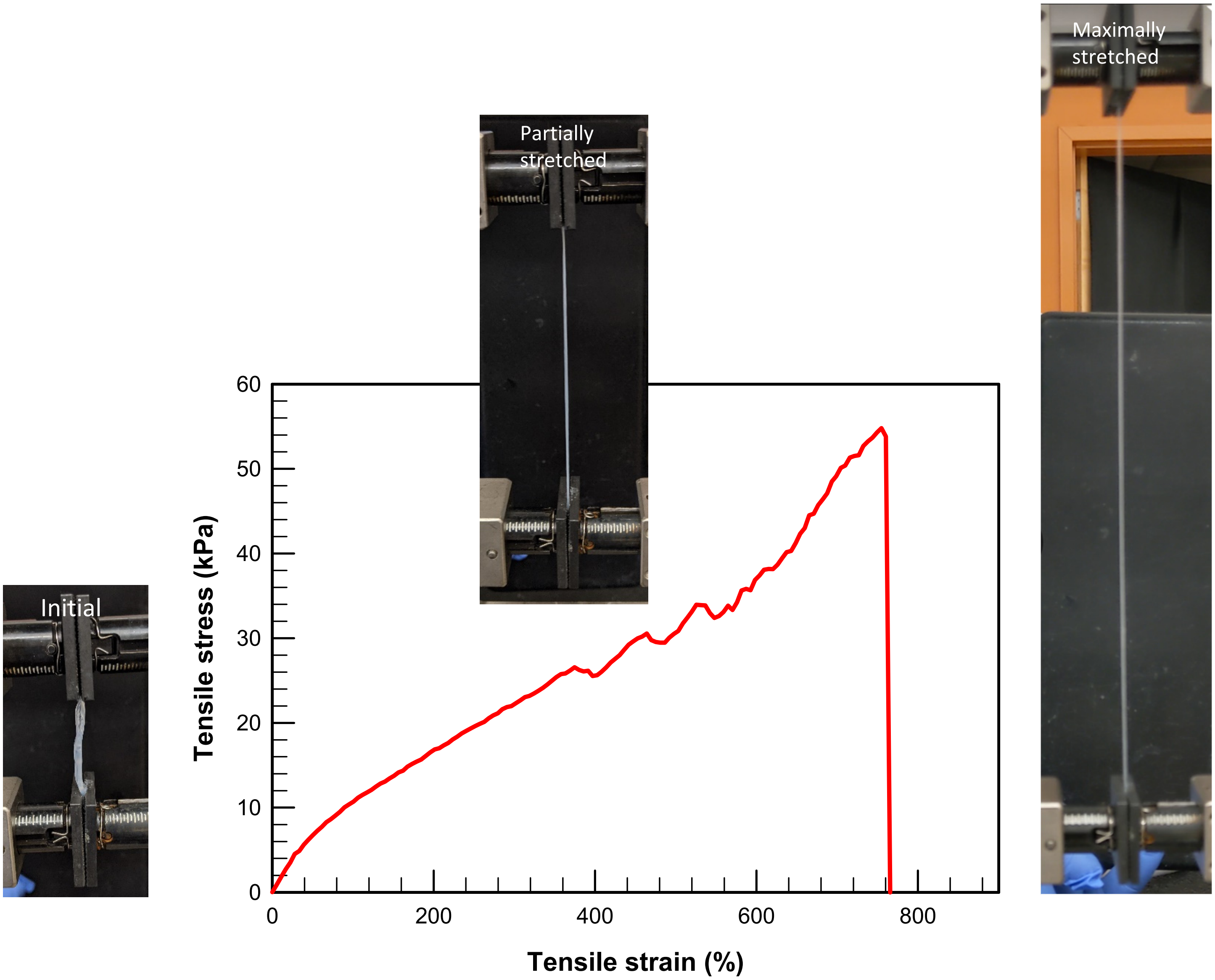

Figure S4. Mechanical properties of tubes under tension. A plot of tensile stress vs. strain is shown for a tube with a single layer of N-isopropylacrylamide (NIPA, 10%) crosslinked with laponite (LAP, 3%) particles. Photos of the tube at diffferent extents of elongation are also shown. The tube can be stretched up to a strain of 750% before it ruptures. From the initial linear portion of the stress-strain curve, the Young's modulus is calculated to be 20 kPa.

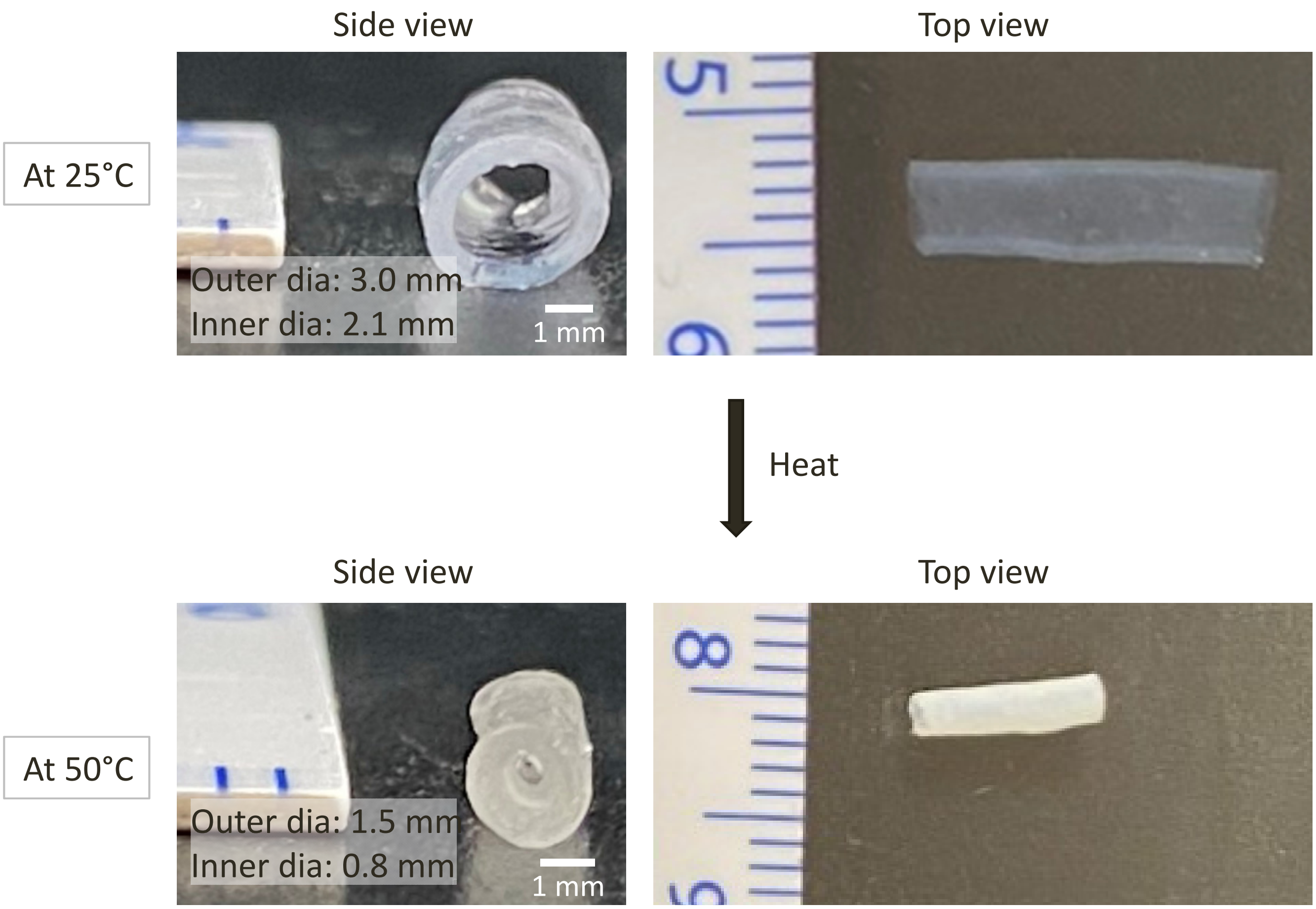

Figure S5. Constriction of a NIPA tube upon heating. The tube with a NIPA wall is shown in two views (side and top) at 25°C and 50°C. At the low temperature, the tube is nearly clear and has an inner diameter of 2.1 mm and an outer diameter of 3.0 mm. When heated above the LCST of NIPA, the tube constricts and becomes opaque. The outer diameter is reduced to 1.5 mm and the inner diameter to 0.8 mm. Similar data are shown for a patterned tube of DMAA-NIPA-DMAA in Figure 4.