Electronic Supplementary Material (ESI) for Soft Matter.
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Electronic Supplementary Information: Poroelastic shape relaxation of hydrogel particles

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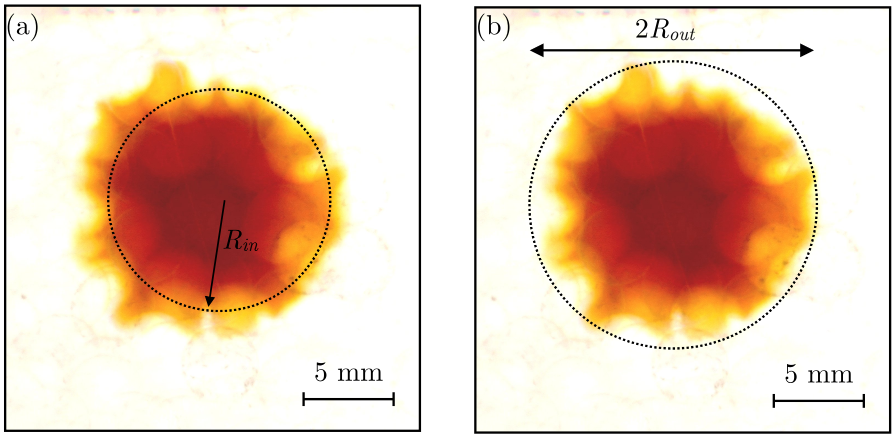

Figure S1 | Determination of characteristic indentation depth. Image corresponding to Fig. 2B showing the (a) inscribed circle of radius R_{in} and (b) circumscribed circle of radius R_{out}, from which the characteristic indentation depth $h \equiv R_{out} - R_{in}$ is determined.

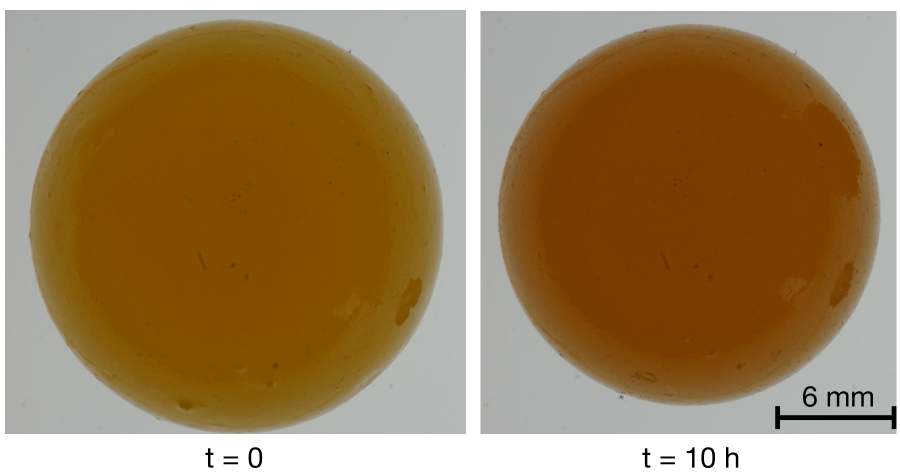

Figure S2 | Minimal influence of drying. To assess the influence of drying, we leave a hydrogel bead swollen in the aqueous NH_4SCN solution on a flat glass surface for 10 h. As shown in the images above, the shrinkage of the swollen bead is minimal — the diameter decreases by only $\sim 8\%$. Moreover, considering that the poroelastic time scale over which the shape relaxation dynamics occur is much shorter, over a time scale ranging from ~ 15 min to ~ 1.5 h, we expect that the influence of solvent evaporation will be minimal.

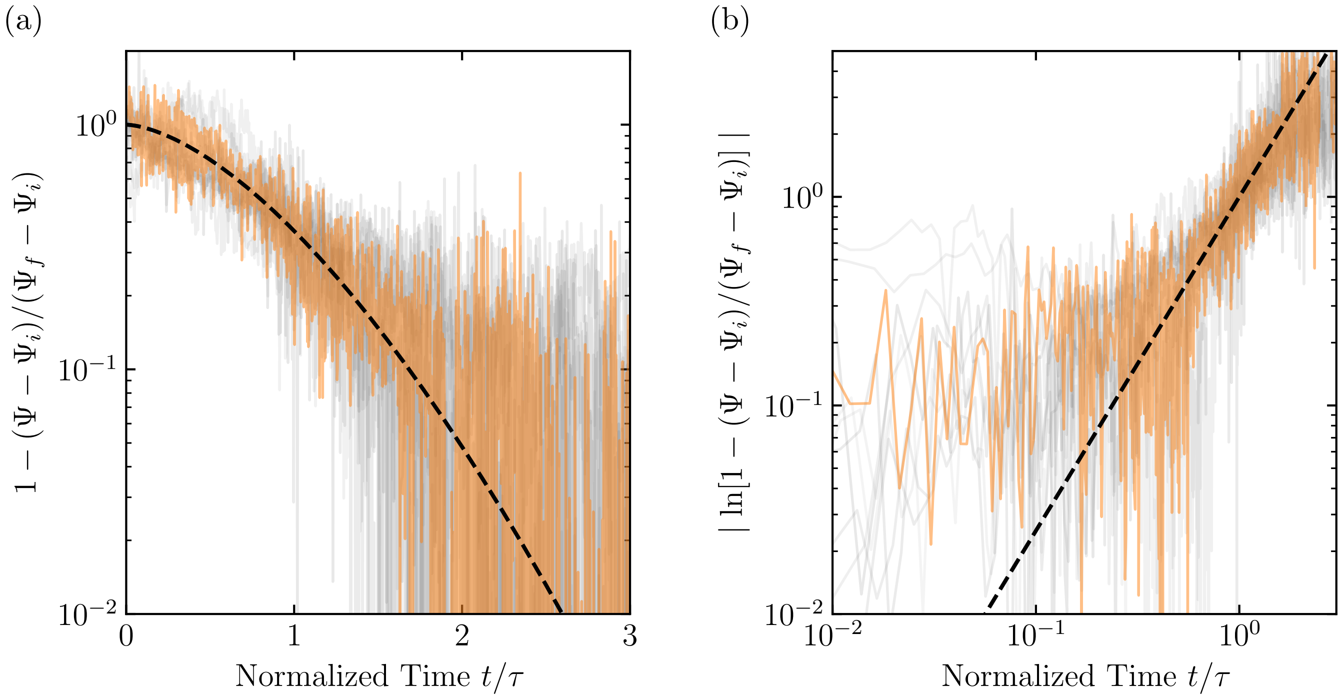

Figure S3 | Measurements of normalized circularity. The measurements of circularity $\Psi(t)$ are fit using the stretched exponential function $\Psi(t) = \Psi_f - (\Psi_f - \Psi_i)\, e^{-(t/\tau)^\beta}$, where Ψ_f, Ψ_i, β, and τ are fitting parameters. To further demonstrate the quality of the fitting, the measurements shown in Fig. 3b are re-plotted in two different ways. (a) We plot $1 - (\Psi(t) - \Psi_i)\,/\,(\Psi_f - \Psi_i)$ versus t/τ with a logarithmic horizontal axis; in this representation, we observe that the data show a slight downward curve, reflecting that the exponent $\beta > 1$. This representation also shows that the fitting works well up to $t \sim 3\tau$, at which point the noise in the measurement dominates. (b) We plot $-\ln[1 - (\Psi(t) - \Psi_i)\,/\,(\Psi_f - \Psi_i)]$ versus t/τ on log-log axes; in this representation, we observe that the data fall on a line whose slope is greater than one, again reflecting that the exponent $\beta > 1$. This representation also shows that the fitting works well except at the shortest times $t < 0.1\tau$ and longest times $t > 3\tau$, which are an order of magnitude smaller and three times larger than the poroelastic time scale of interest τ, respectively.

Determining poroelastic relaxation dynamics by tracking the position of individual points on the hydrogel surface. In a given experiment, we track three different points at the hydrogel surface; we note that an alternative method could be to track the distance between pairs of adjacent points on the hydrogel surface. In particular, for each point i, we binarize our images of the hydrogel using a given threshold value and track the position R_i of the point over time t. In some cases, slight drying or movement of the hydrogel introduces a linear offset to these measurements, which we subtract from the data; we then fit $R_i(t)$ with an exponential function as shown in Fig. 3a, which yields $\tau_i \pm \delta\tau_i$, where the uncertainty $\delta\tau_i$ reflects the uncertainty in the least-squares fitting. Taking the mean of the three τ_i thus obtained for a given hydrogel yields the relaxation time τ (circles in Fig. 4) while propagating the uncertainties $\delta\tau_i$ yields the overall uncertainty (vertical error bars on the circles in Fig. 4).

Determining poroelastic relaxation dynamics by tracking the overall circularity of the hydrogel. In a given experiment, we binarize our images of the hydrogel using a given threshold value and track the overall circularity Ψ over time t. We then fit $\Psi(t)$ with the stretched exponential function $\Psi(t) = \Psi_f - (\Psi_f - \Psi_i)\, e^{-(t/\tau)^\beta}$, where Ψ_f, Ψ_i, β, and τ are fitting parameters; this function simply serves as a phenomenological fitting function that provides a good fit to the data as shown in Fig. 3b. For all of our measurements, the exponent of the stretched exponential $\beta = 1.5 \pm 0.8$, in close agreement with previous measurements of poroelastic relaxation (Refs. 63, 71-73) that reported $0.4 \leq \beta \leq 2.4$. Our fits yield $\Psi_f = 0.894 \pm 0.008$ and $\Psi_i = 0.85 \pm 0.03$. However, it is important to note that the absolute values of Ψ_i and Ψ_f depend on the resolution and magnification of the images used—a well known consequence of pixelization, as described in Ref. 70. To assess the uncertainty in τ, we re-fit the data obtained upon varying this threshold value by $\pm 5\%$, for which the binarized images still closely approximate the shape of the imaged hydrogel. The resulting standard deviation in the values of τ thus obtained yields the reported uncertainty in τ. The uncertainty associated with determining τ from the least-squares fitting procedure itself is two orders of magnitude smaller; we therefore neglect it from our analysis.