# Poroelastic properties of hydrogel microparticles

Joseph D. Berry,[1,*] Matthew Biviano,[1] and Raymond R. Dagastine[1,†]

[1]*Department of Chemical Engineering,*
*University of Melbourne, Parkville, Victoria 3010, Australia*

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## SUPPLEMENTAL MATERIAL

* joe.d.berry@gmail.com

† rrd@unimelb.edu.au

[1] Z. I. Kalcioglu, R. Mahmoodian, Y. Hu, Z. Suo, and K. J. Van Vliet, Soft Matter **8**, 3393 (2012).

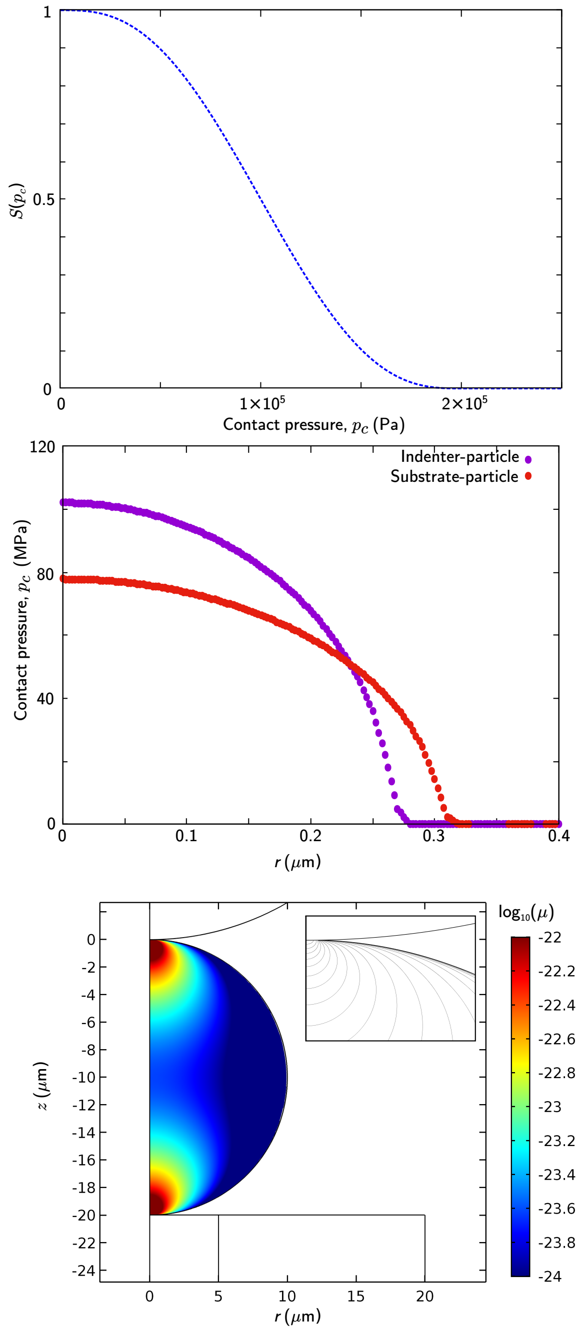


FIG. S1. a) Smoothing function used in the Robin boundary condition to ensure that there is zero flux of solvent from the poroelastic material into the indenter in the contact region, and the Dirichlet condition $\mu = \mu_0$ elsewhere on the boundary. b) The contact pressure due to the indenter and the substrate after 1 s of constant indentation. c) Contours of chemical potential $\mu$ in the initial stages of the indentation process, showing that away from the contact region the boundary condition is $\mu = \mu_0 = 10^{-24}$ J, whereas in the contact region the boundary condition is zero flux.

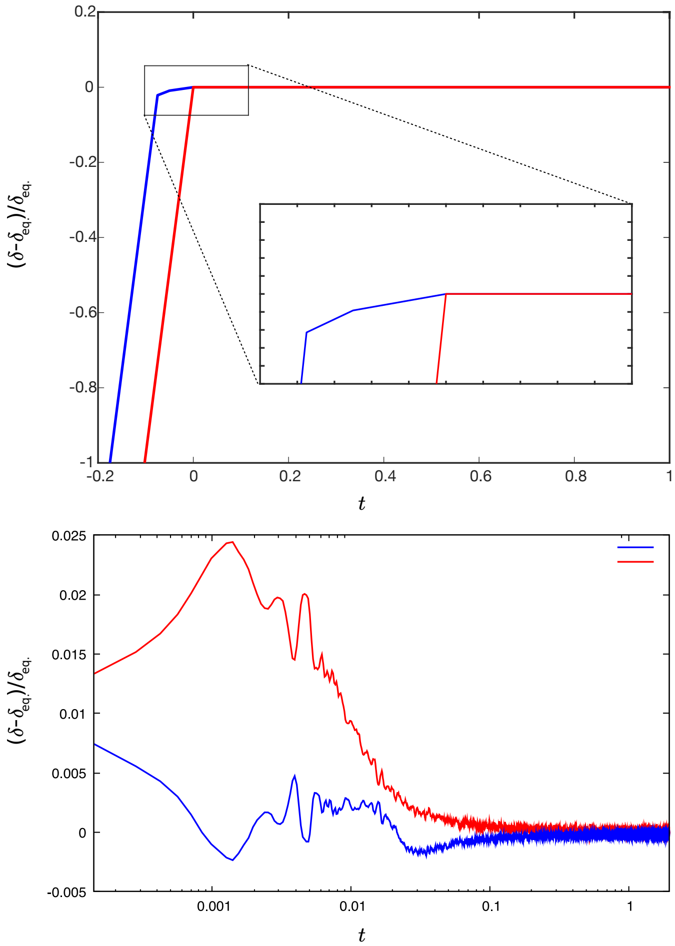


FIG. S2. a) Example of two alternative AFM drive profiles used to attain a constant equilibrium indentation depth $\delta_{\mathrm{eq.}}$. The red line represents a drive profile without adjustment, where the cantilever with probe attached approaches and indents the poroelastic material at a speed of 40 $\mu$m/s until the specified force trigger is reached, whereupon the cantilever is held in position for a specified period of time ($\sim$ 1 s). The blue line represents a drive profile adjusted to minimise overshoot. Here, the cantilever approaches and indents the sample at a speed of 40 $\mu$m/s for a prescribed distance, then slows to a speed of 2 $\mu$m/s for 0.05 s, slows further to a speed of 0.75 $\mu$m/s for 0.025 s, and then finally is held in position for a specified period of time. b) The corresponding error in the indentation depth during the dwell as a function of time for each drive profile, showing that the error is $< 1\%$ using the three-stage approach profile, compared to $\sim 2.5\%$ for the one-stage approach profile.

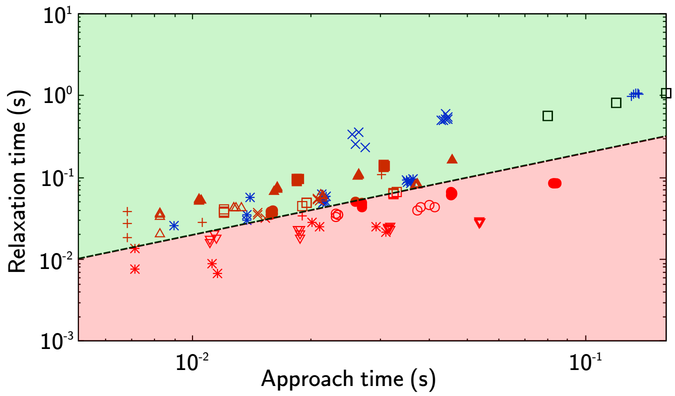


FIG. S3. Relaxation time plotted against approach time for all experimental measurements considered. The red symbols represent particle measurements, blue symbols represent film measurements, and the black symbols are the measurements of Kalcioglu *et al.*[1]. The approach time is calculated from the AFM force curves as the time between contact and the start of the dwell. The relaxation time is estimated using $\tau = a^2/D$, where the contact radius $a$ is calculated from the indentation depth $\delta$ and the indenter radius $R$, and the diffusivity $D$ is estimated by fitting the force relaxation with the master curve (Eq. 13). The dashed black line represents the threshold where the approach time is half the relaxation time. Any data where the approach time is greater than half the relaxation time (represented by the red shaded region) is not used in the final analysis presented in the paper.