

## Supplementary Materials for

### **Cation-induced shape programming and morphing in protein-based hydrogels**

Luai R. Khoury\*, Marina Slawinski, Daniel R. Collison, Ionel Popa\*

\*Corresponding author. Email: [popa@uwm.edu](mailto:popa@uwm.edu) (I.P.); [khoury@uwm.edu](mailto:khoury@uwm.edu) (L.R.K.)

Published 29 April 2020, *Sci. Adv.* **6**, eaba6112 (2020)

DOI: [10.1126/sciadv.aba6112](https://doi.org/10.1126/sciadv.aba6112)

#### **The PDF file includes:**

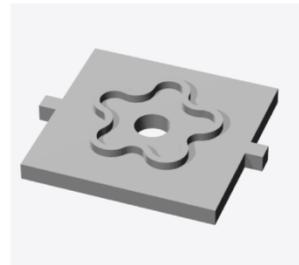
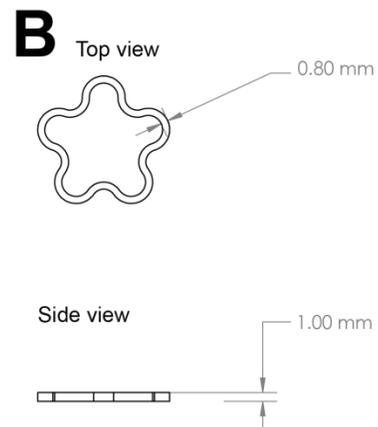
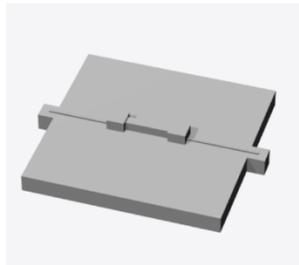
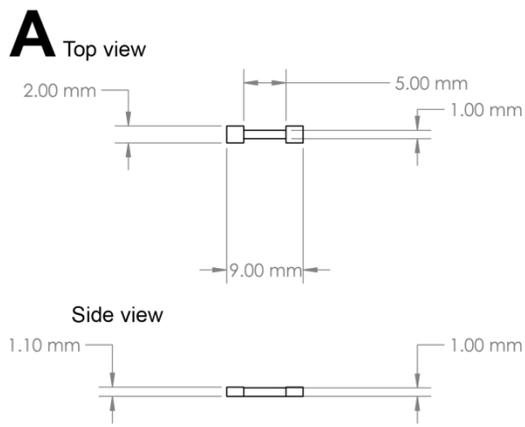
Figs. S1 to S3

Legends for movies S1 to S3

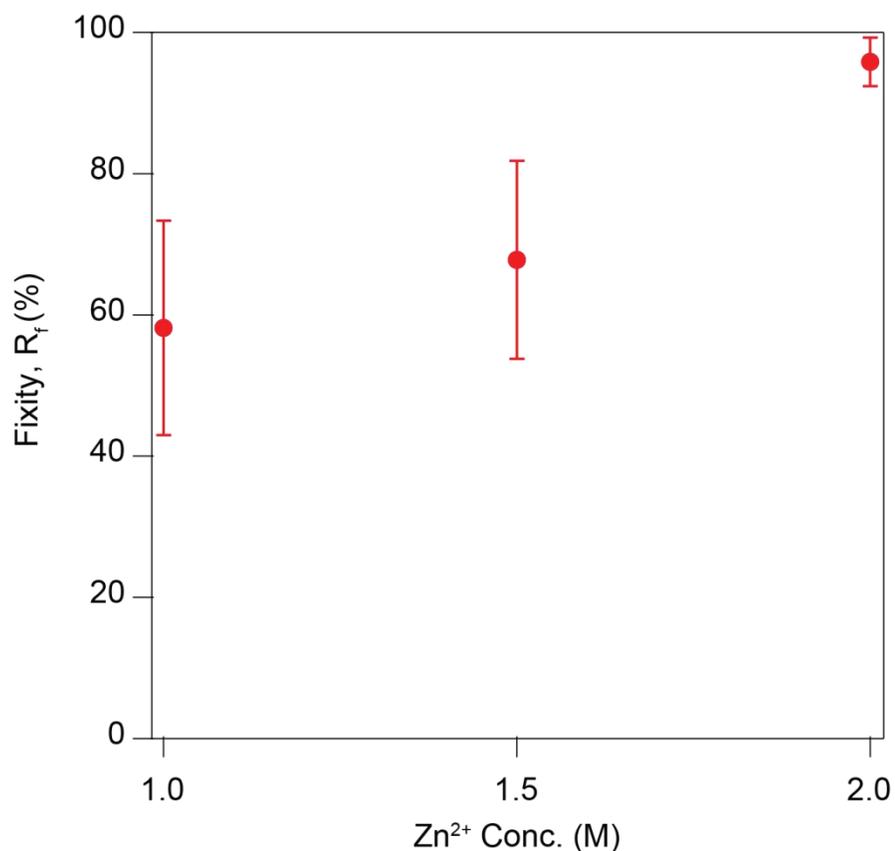
#### **Other Supplementary Material for this manuscript includes the following:**

(available at [advances.sciencemag.org/cgi/content/full/6/18/eaba6112/DC1](https://advances.sciencemag.org/cgi/content/full/6/18/eaba6112/DC1))

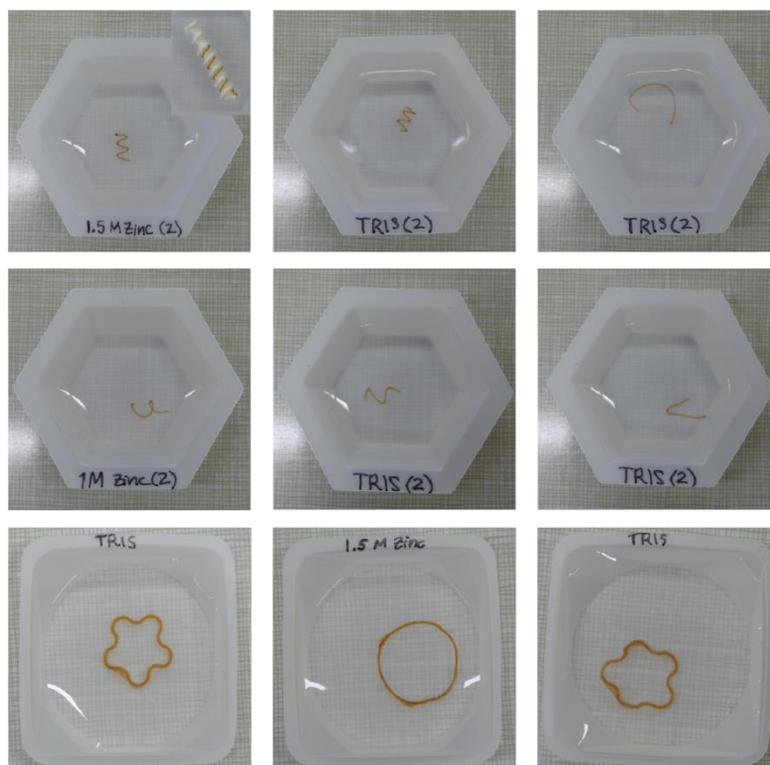
Movies S1 to S3



**Supplementary Figure 1.** Schematics showing the two different shapes used in this study to synthesize hydrogels: (A) bone-like shape, (B) Flower-like shape.



**Supplementary Figure 2.** Changes in the measured fixity ratio of U-shape hydrogel as a function of Zn<sup>2+</sup> concentration. The fixity represents the ratio between the bending angle following the programming step, when the hydrogel is taken out of the mold ( $\theta$ ) and the programmed angle (180 deg) of the mold. Inset: Pictures of the U-shape gels after being removed from the mold at different Zn<sup>2+</sup> concentrations (photo credit: Luai R. Khoury, UWM; Marina Slawinski, UWM).



**Supplementary Figure 3.** Additional Examples of cation-induced shape morphing for protein hydrogels. BSA hydrogels were casted in cylindrical shape using PTFE tubes (top and middle left) and flower-like silicone rubber mold (bottom left). Then, they were programmed in a spring shape or ring shape, respectively, by immersion in 1.5 M  $\text{Zn}^{2+}$  solution (top and bottom) or 1 M  $\text{Zn}^{2+}$  (center) for 30 min. Afterwards, the programmed hydrogels were moved to TRIS buffer causing the hydrogels to recover to their casted shapes (photo credit: Luai R. Khoury, UWM; Marina Slawinski, UWM)

**Supplementary Movie 1.** Movie showing the morphing of a BSA-hydrogel casted as a ring and programmed into a flower in 2 M  $\text{Zn}^{2+}$  for 30 min and immersed in PBS buffer. As  $\text{Zn}^{2+}$  diffuses outside the hydrogel, the flower shape morphs into the initial ring shape.

**Supplementary Movie 2.** Movies showing the morphing of BSA-hydrogels casted as a cylinder and programmed as a spring shape in 2 M  $\text{Zn}^{2+}$ .

**Supplementary Movie 3.** Movie showing the morphing of BSA-hydrogels casted as a cylinder and programmed in a U-shape in 2 M  $\text{Zn}^{2+}$ .