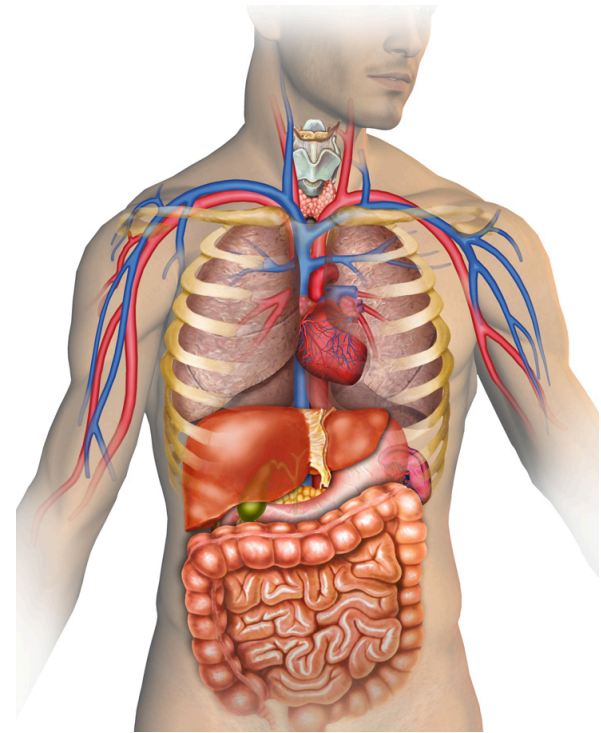
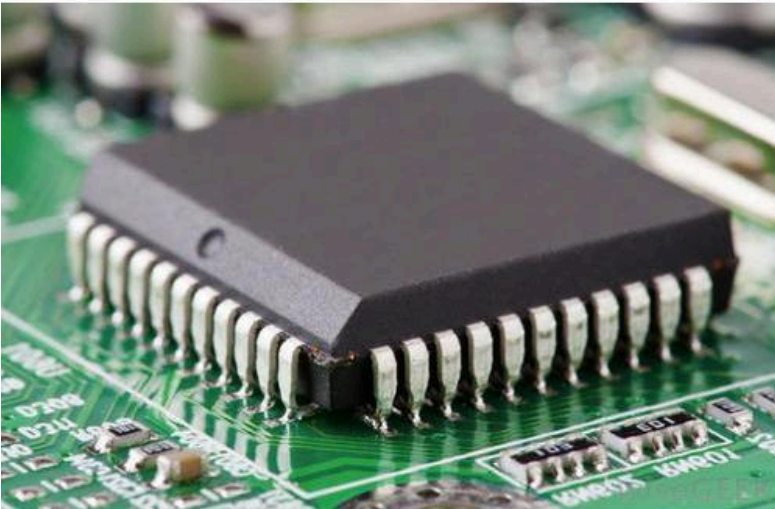


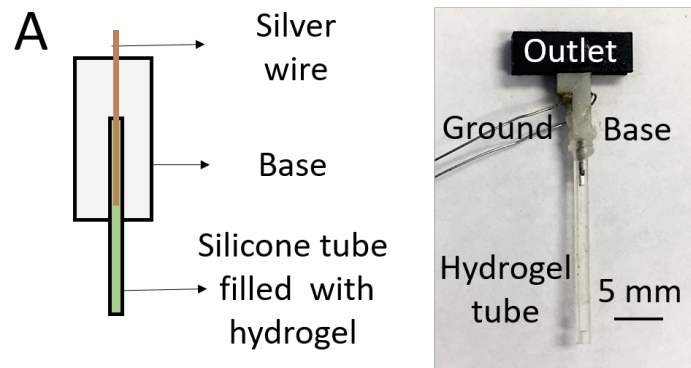
integrated soft materials

Zhigang Suo

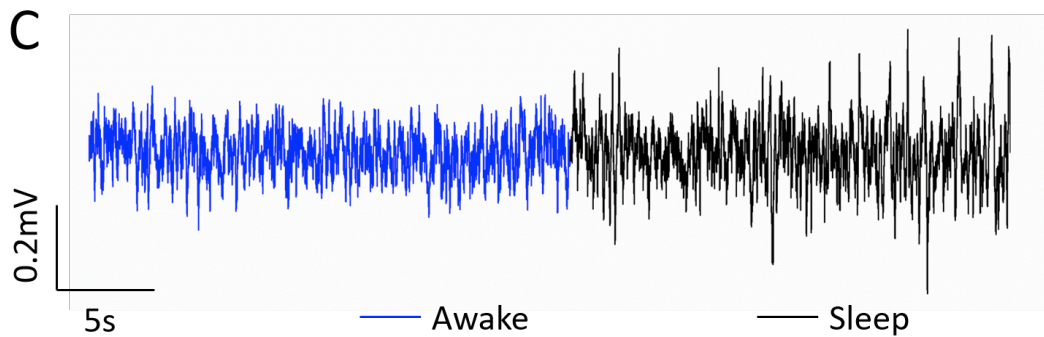
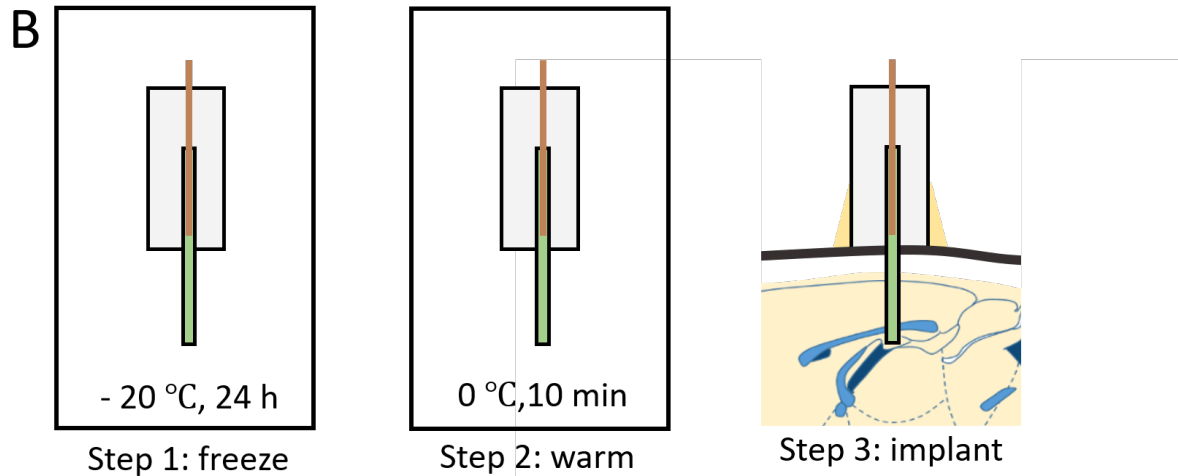
Harvard University

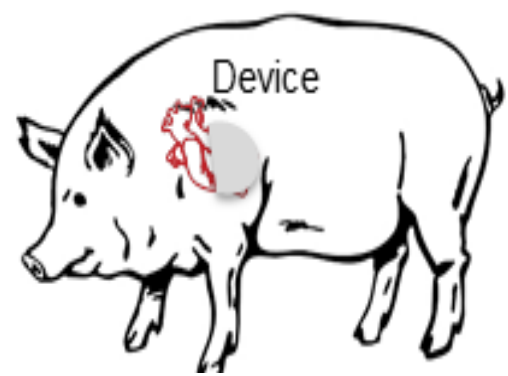
Function by integration





Neurohydrogel



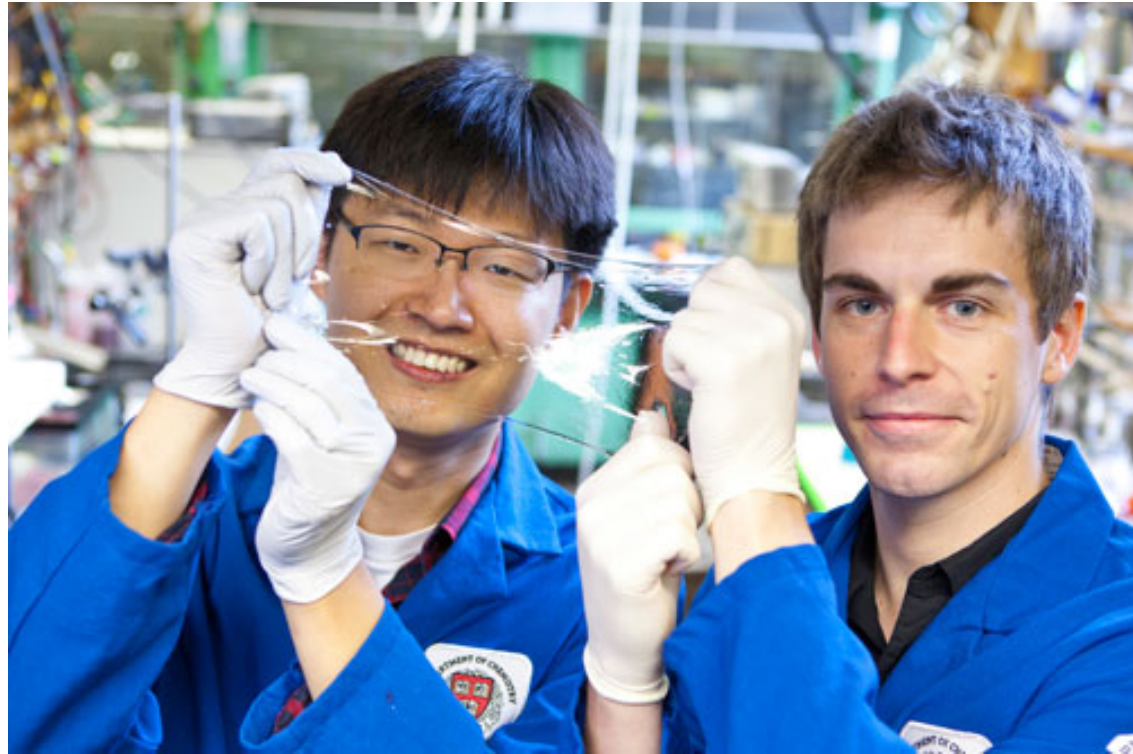
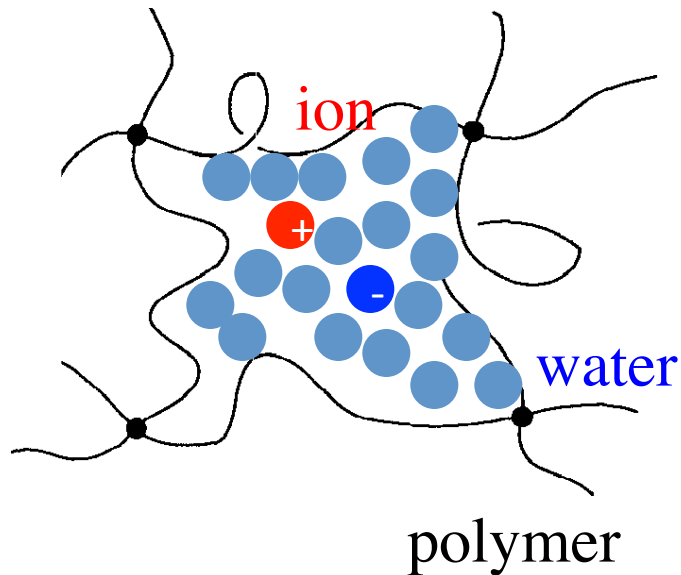


Hydrogel-tissue

- Wound closure
- Drug delivery

Stretchable, transparent, ionic conductors

Hydrogel



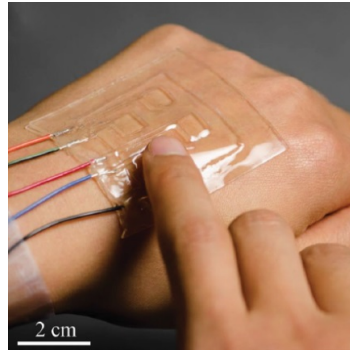
Create function through integration

ionic music (iTune)

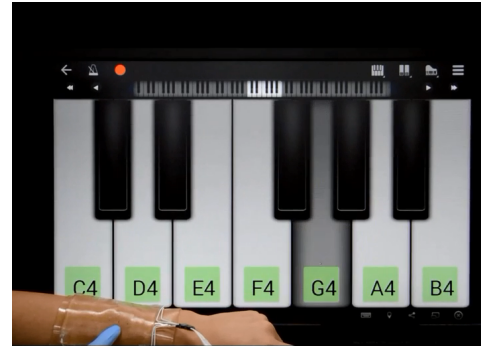


Science 2013

ionic touchpad (iPad)

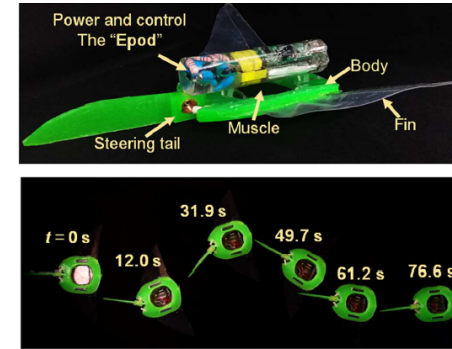


Advanced. Materials 2014



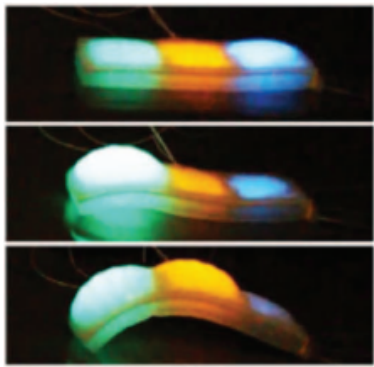
Sun, et al. Science 2016

ionic robot (iBot)

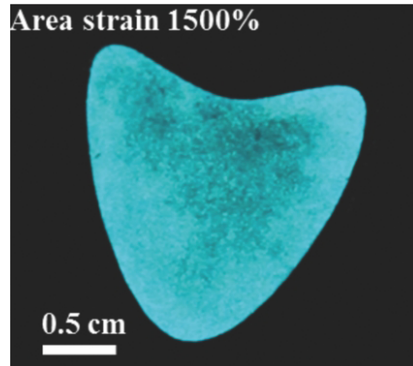


Li, et al. Sci. Adv. 2016

electroluminescence



Larson et al. Science 2016

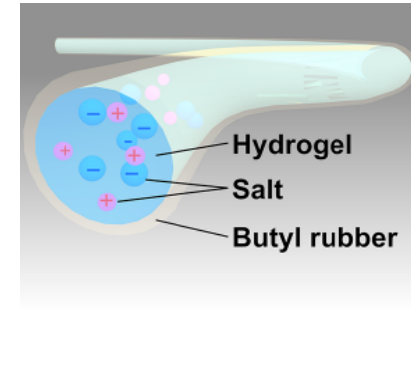


Advanced Materials 2016

artificial axon

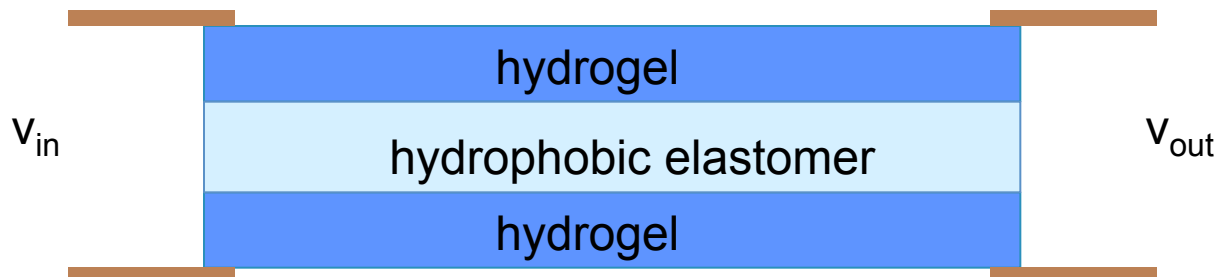
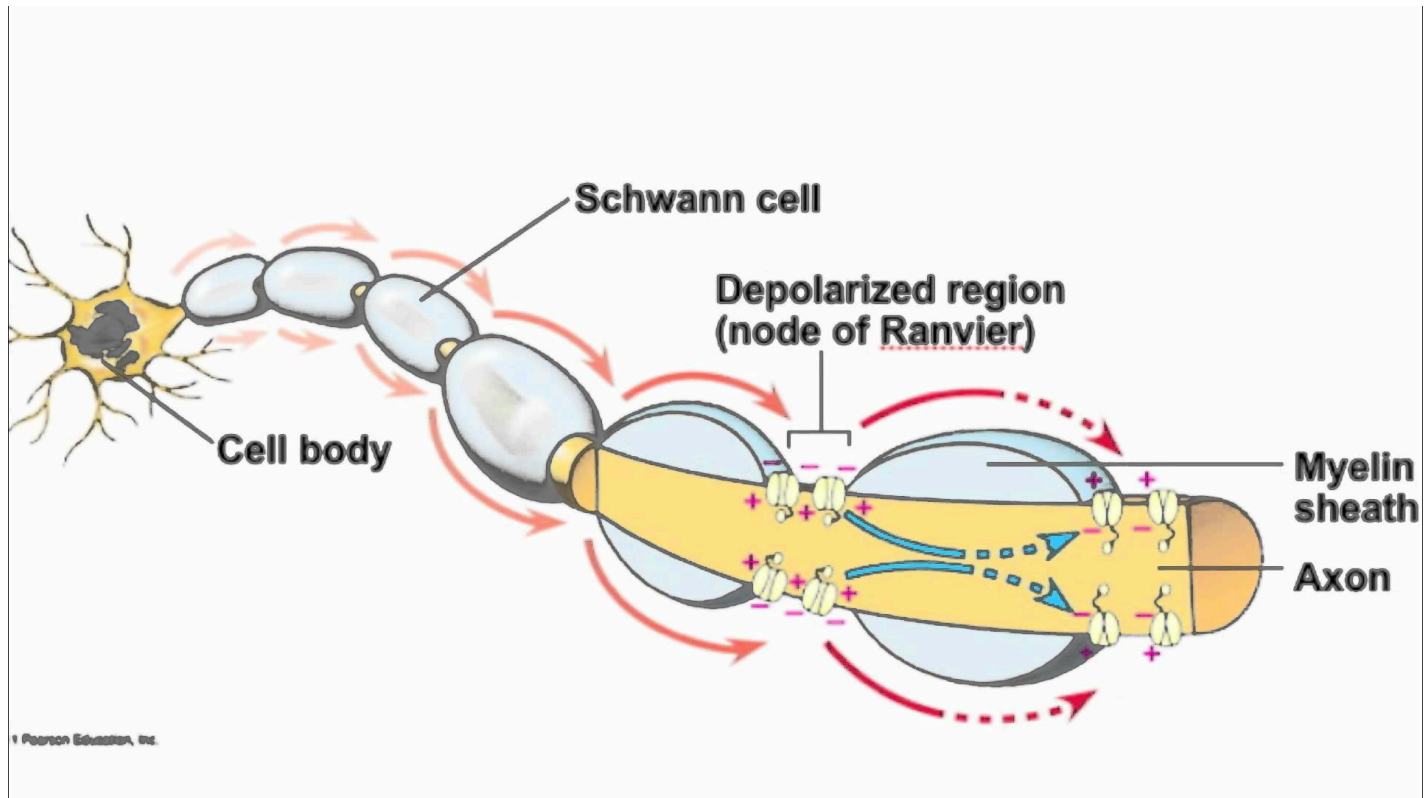


EML 2015



AMI 2017

Axon, natural and artificial

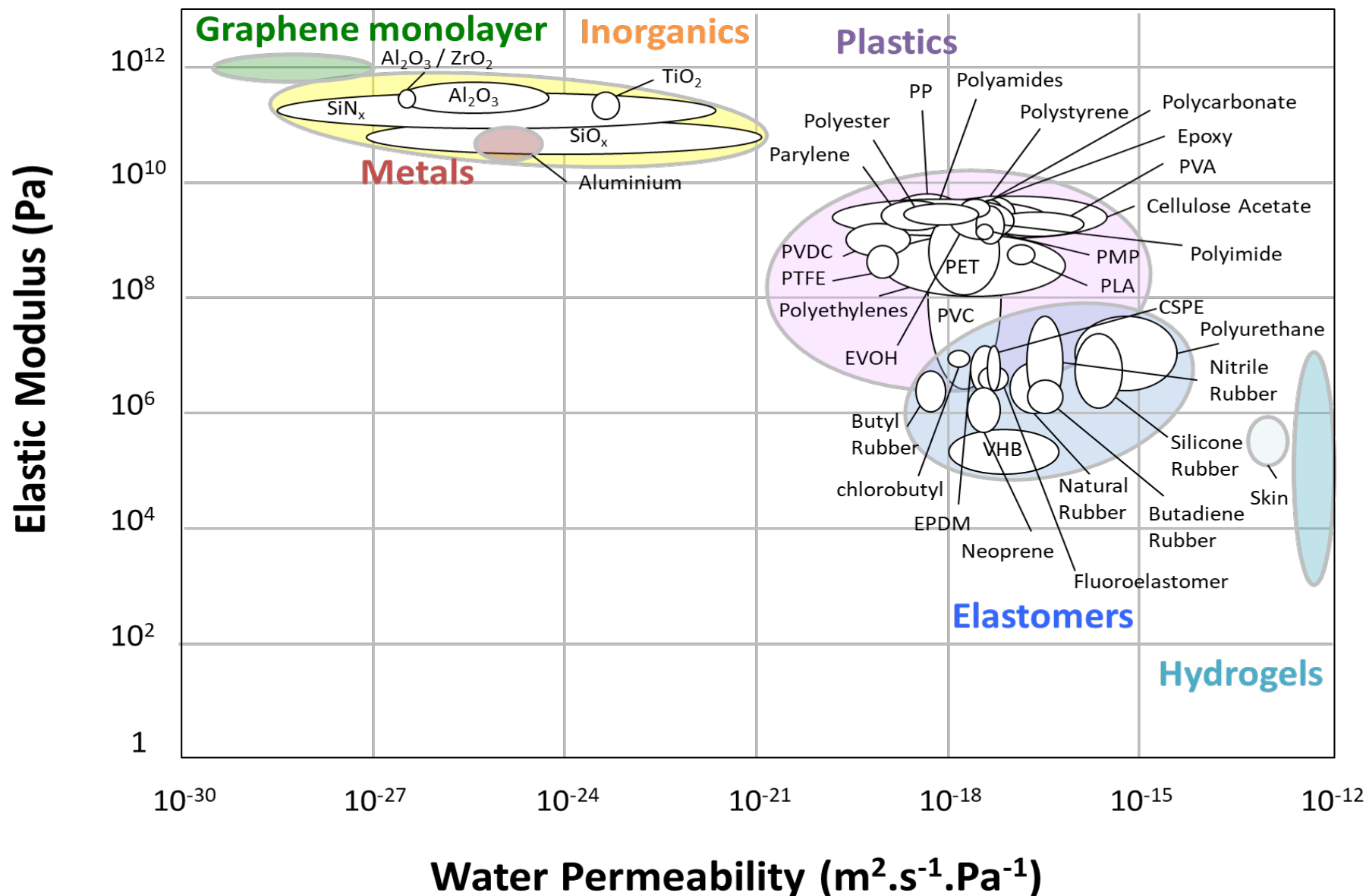


Hydrogel-elastomer

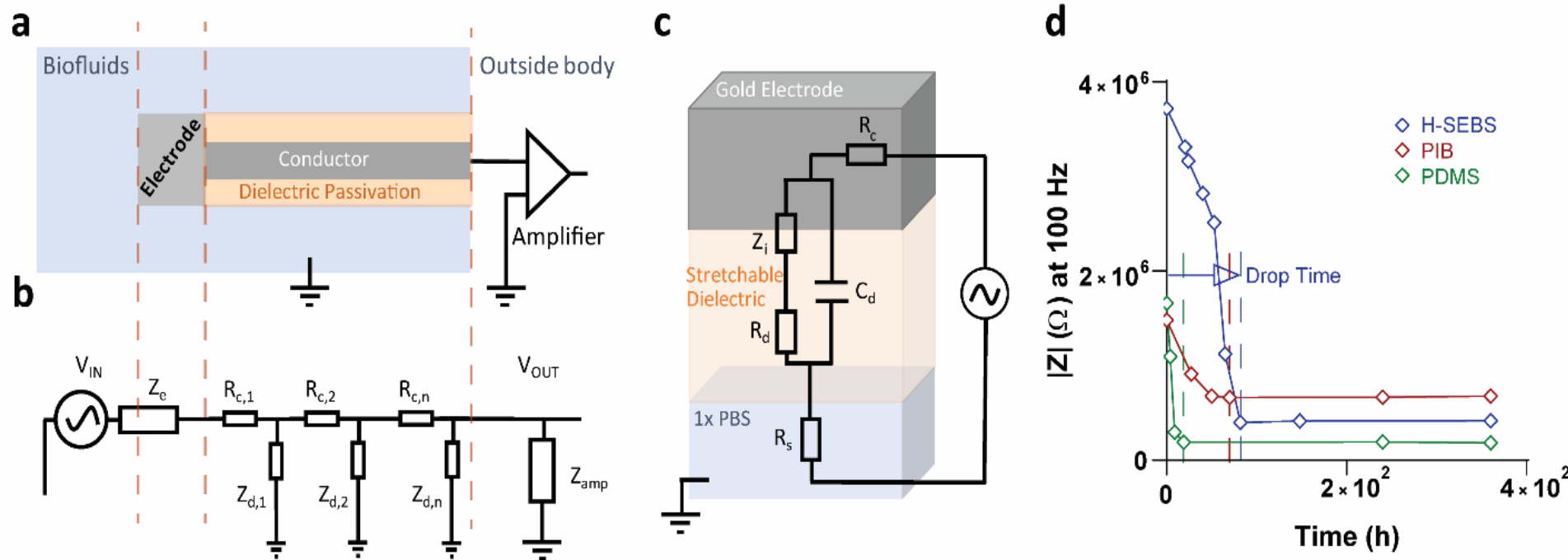
ionic cable (artificial axon)



Stretchable electronics are naked



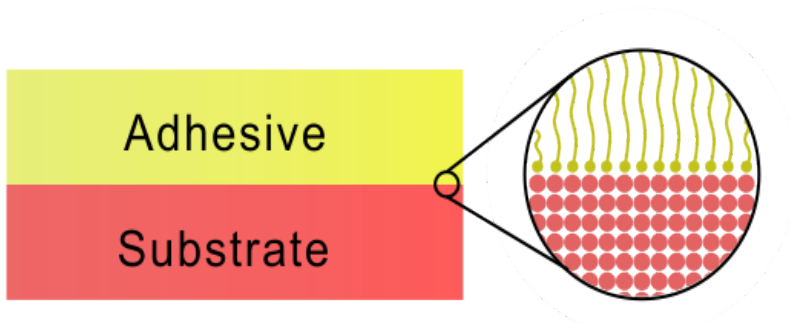
Permeation of ions through elastomers sets a fundamental limit to bioelectronics



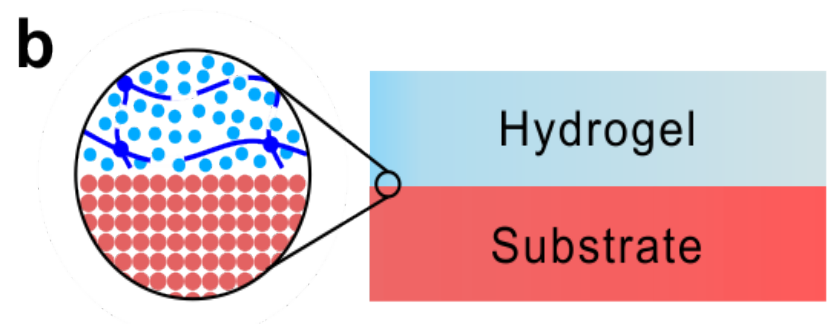
Why is hydrogel adhesion weak?

It's water.

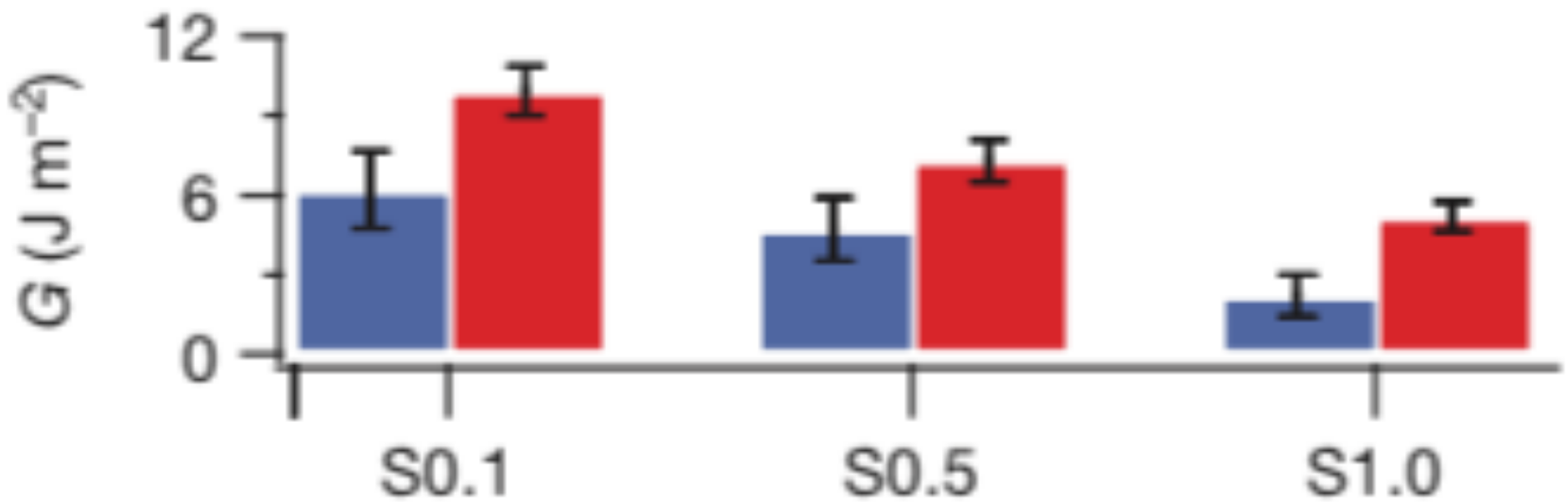
a



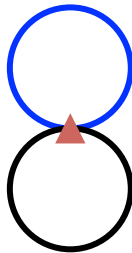
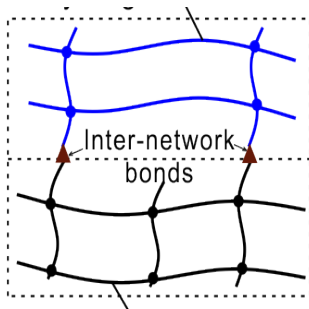
b



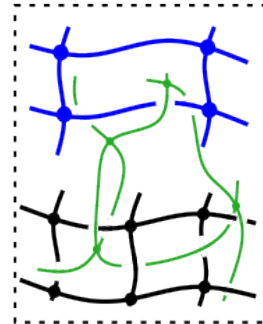
Hydrogel often has weak adhesion



Bond

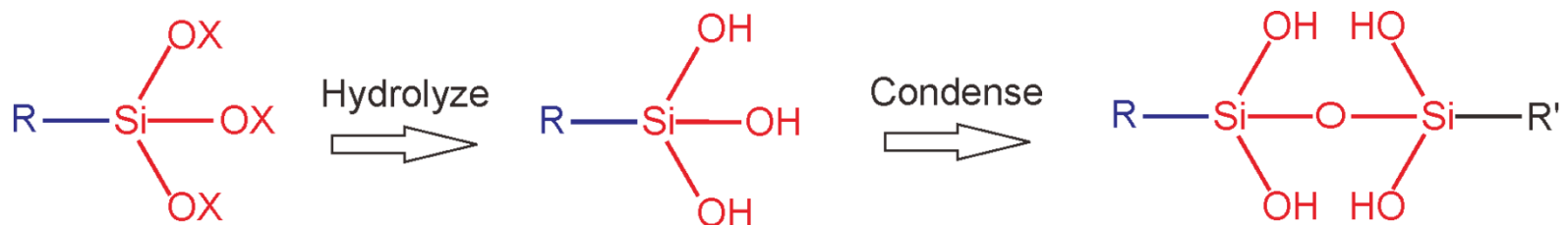
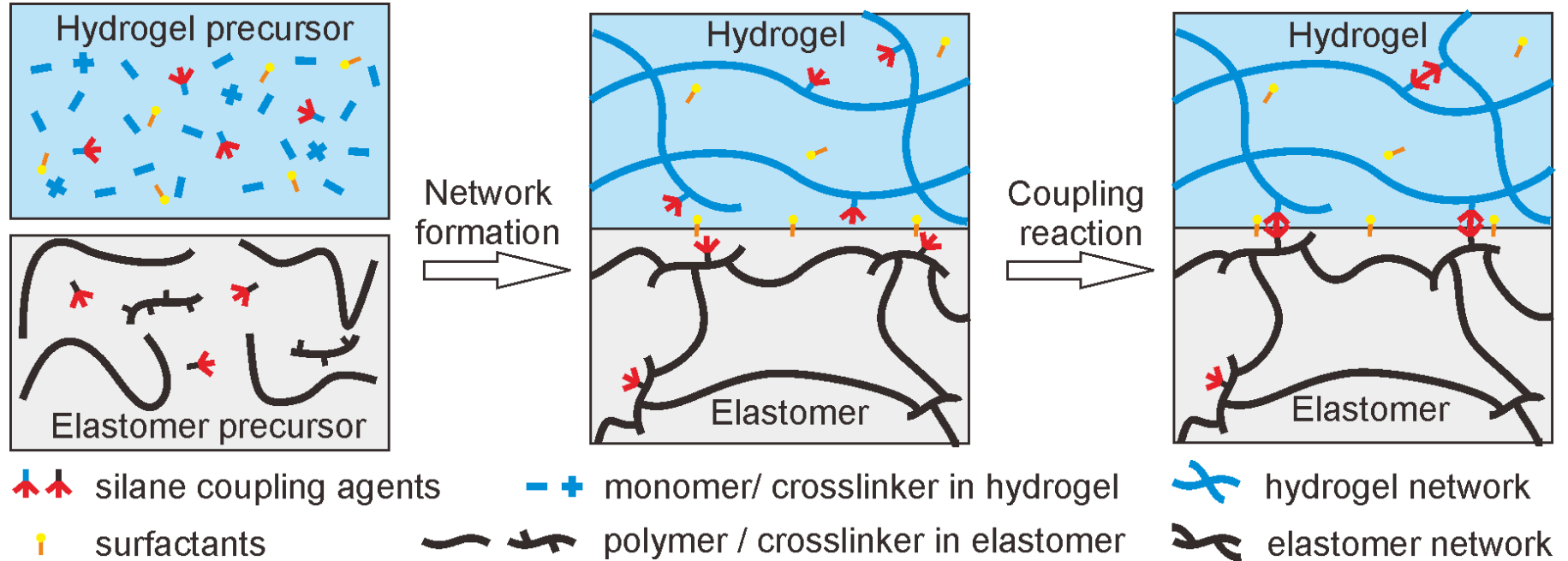


stitch



Yang, Bai, Suo. Advanced Materials (2018)
Yang, Suo. Nature Reviews Materials 3, 125 (2018)

Volume modification

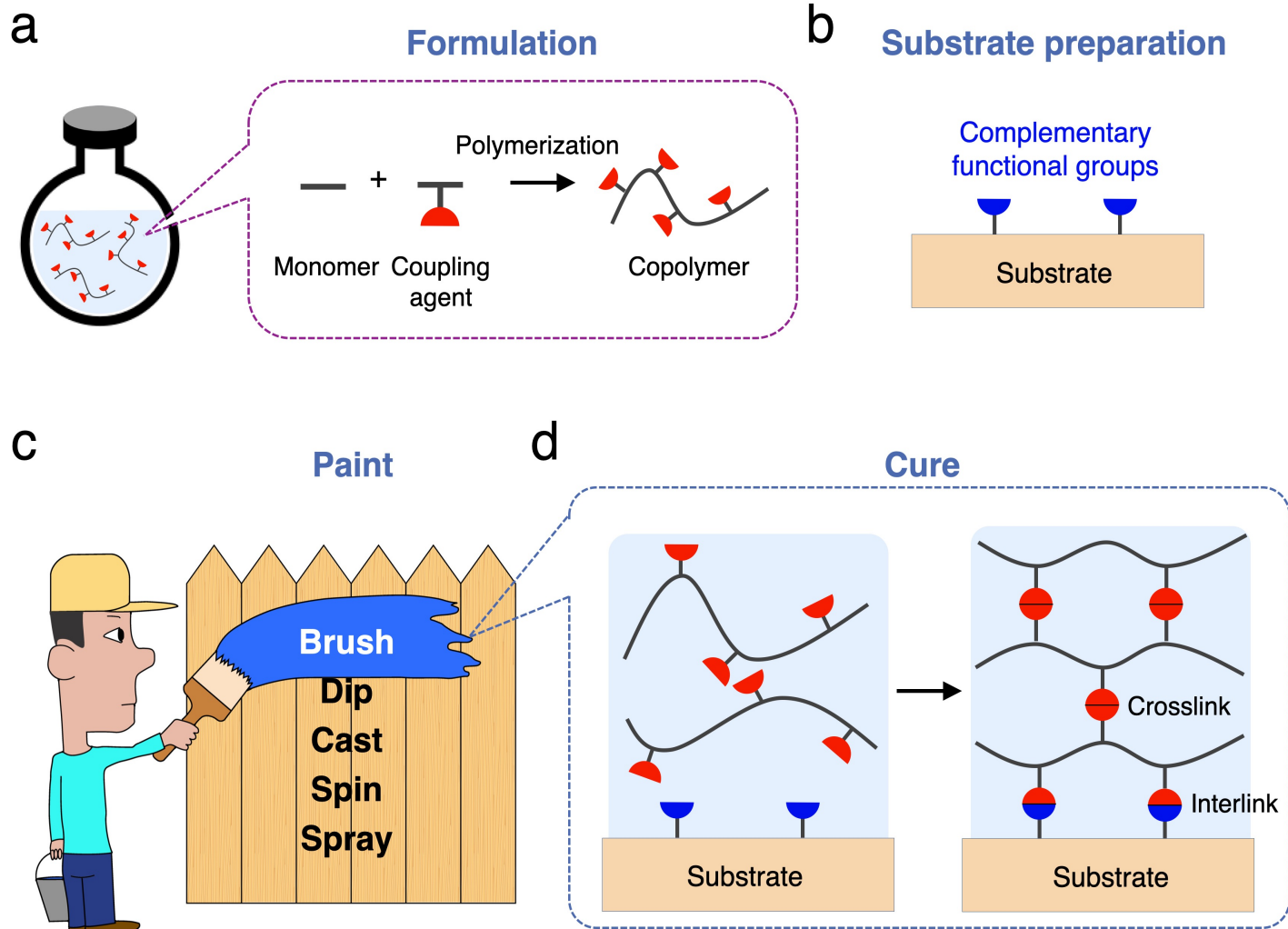


Deep-fry hydrogel

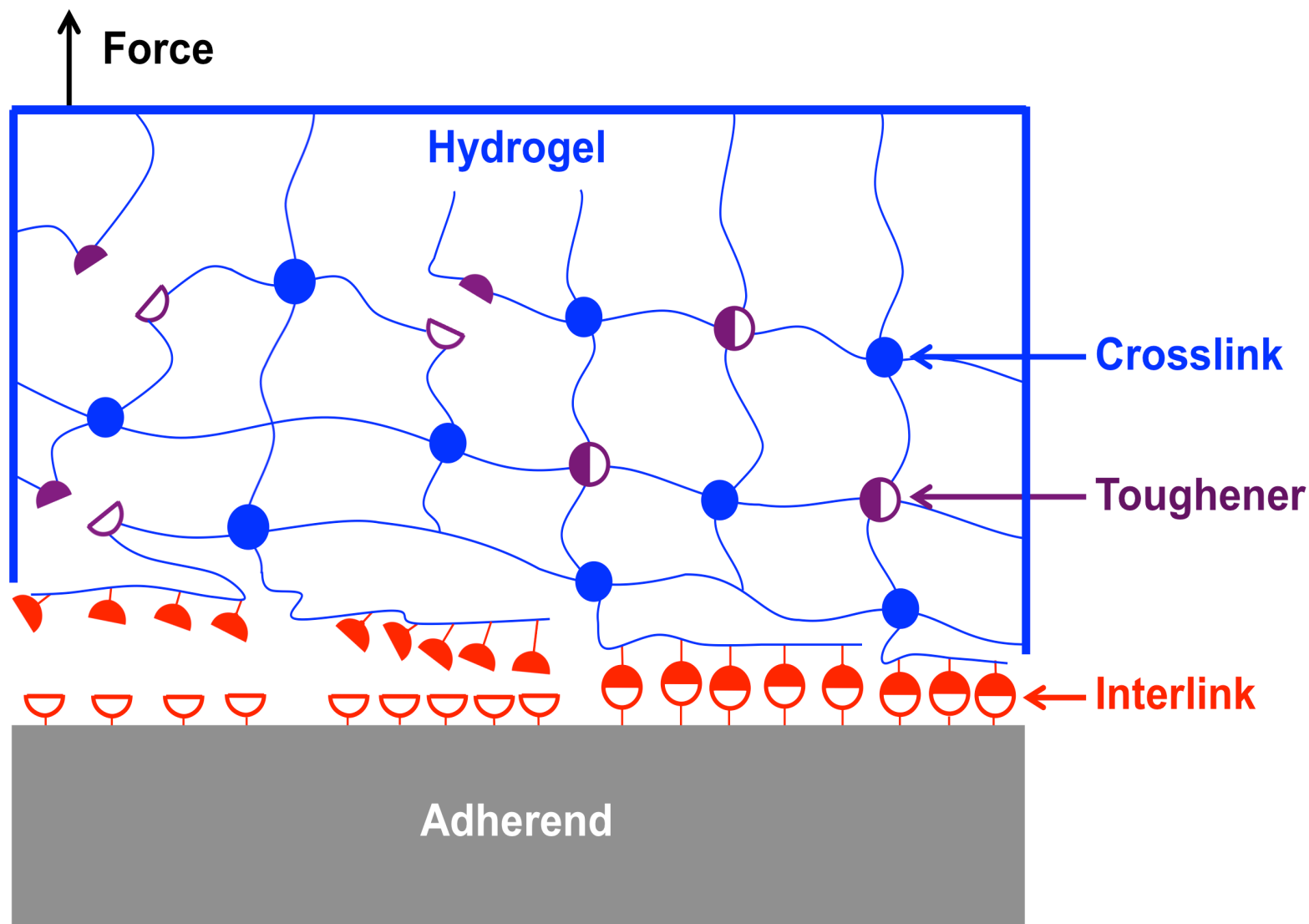


Hydrogel paint

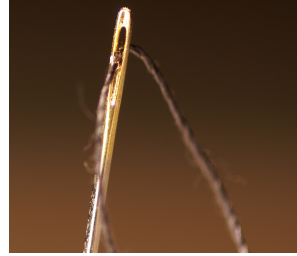
A division of labor between paint maker and paint user



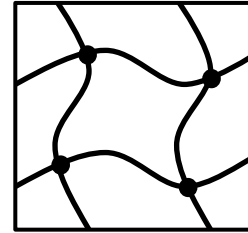
Instant, tough, noncovalent adhesion



Molecular suture



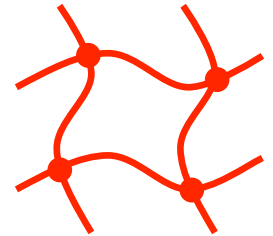
Holes: preexisting polymer networks (~ 10 nm)



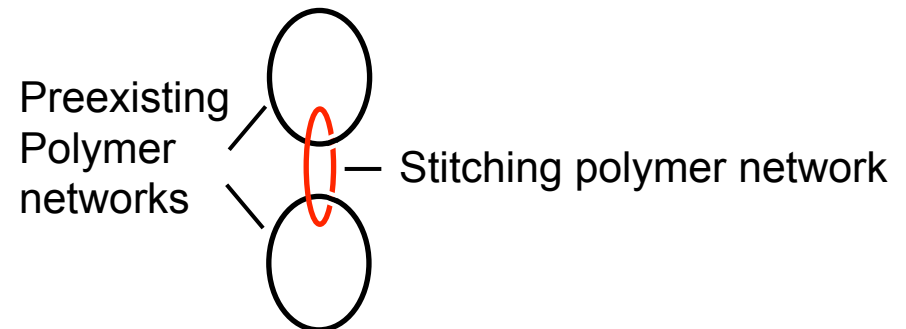
Threads: Polymer chains (~ 100 nm)



Knots: polymer chains form a network *in situ*



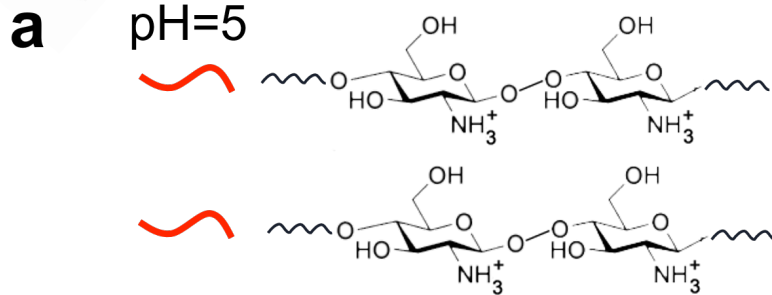
Topological entanglement



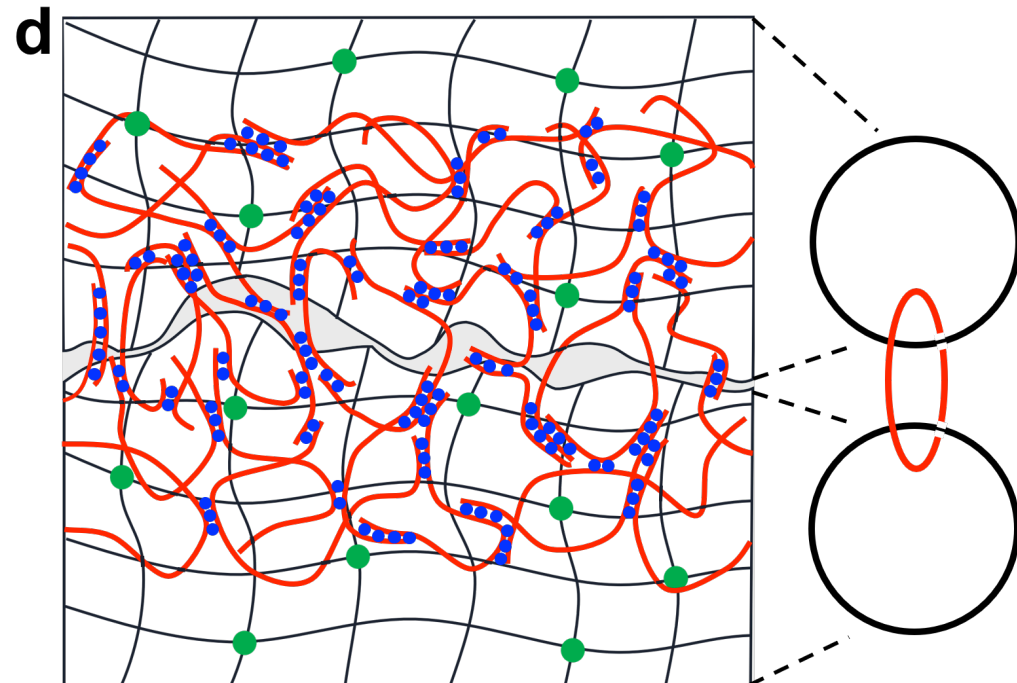
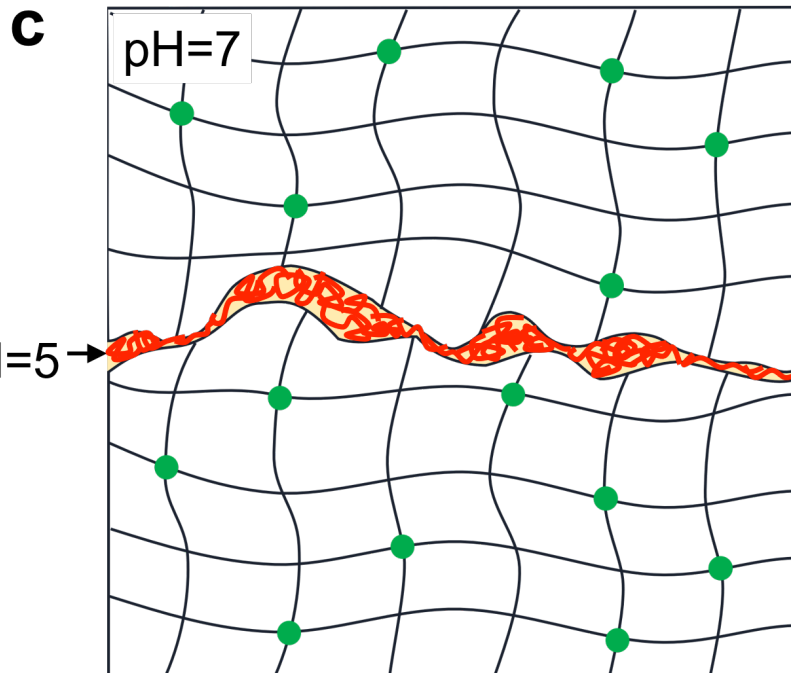
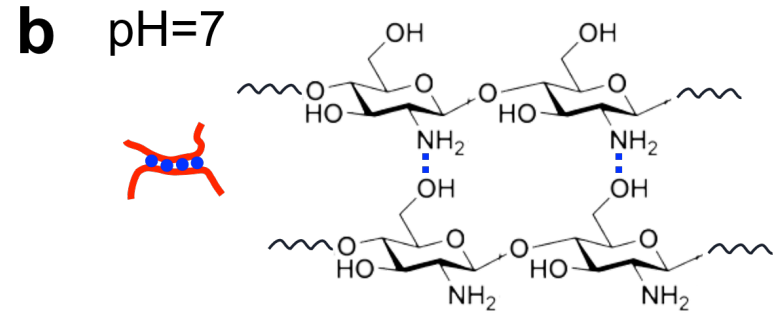
Topological adhesion



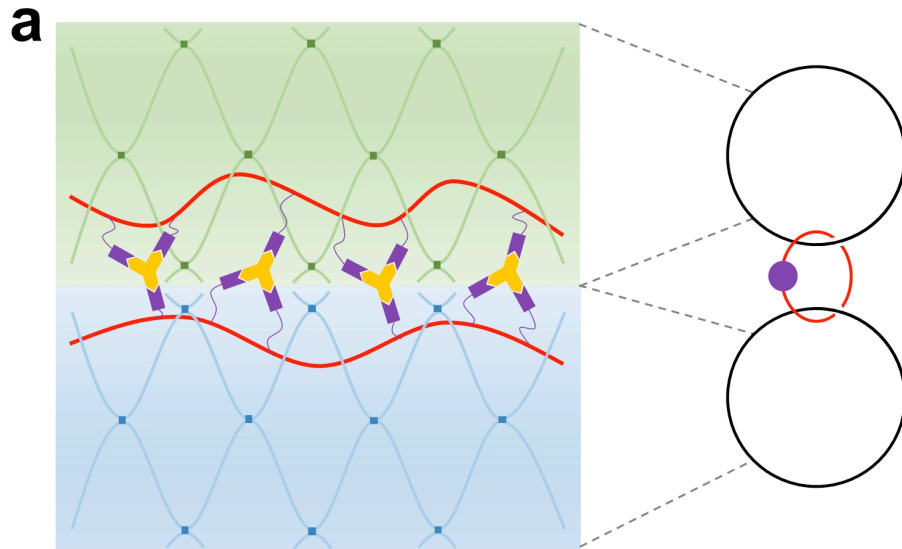
Chitosan solution



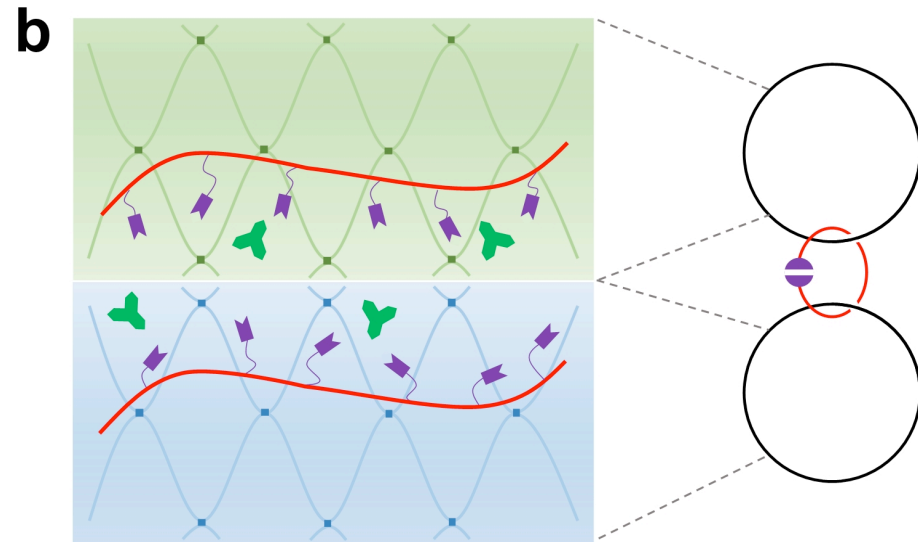
Hydrogen-bonded complex



Photodetachable adhesion

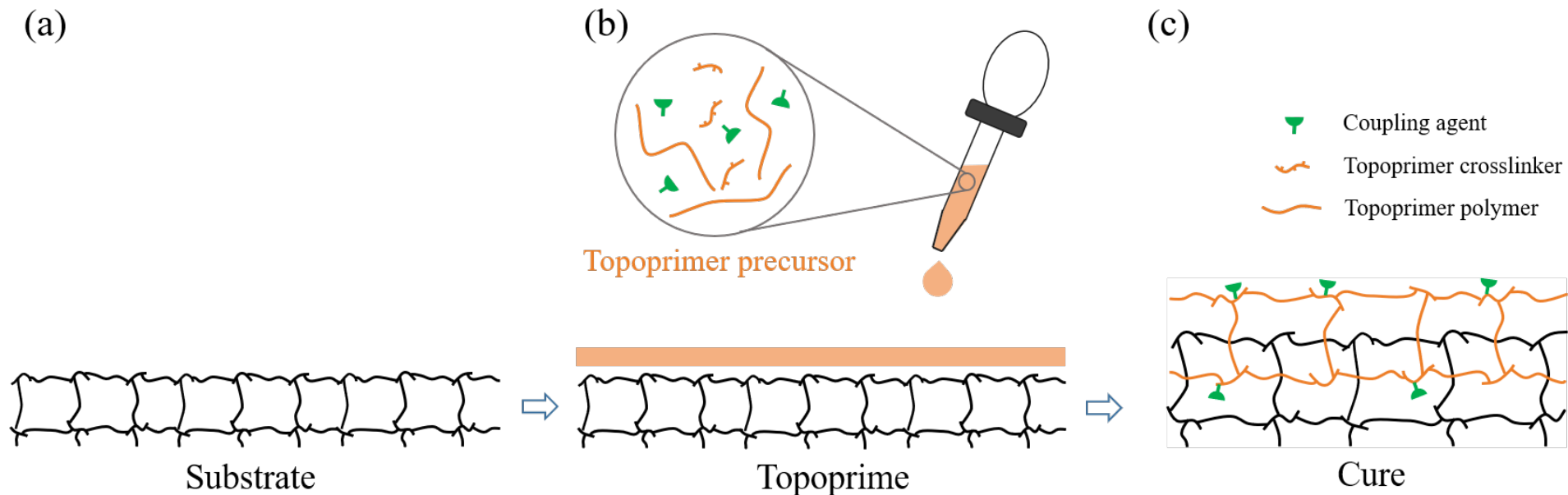


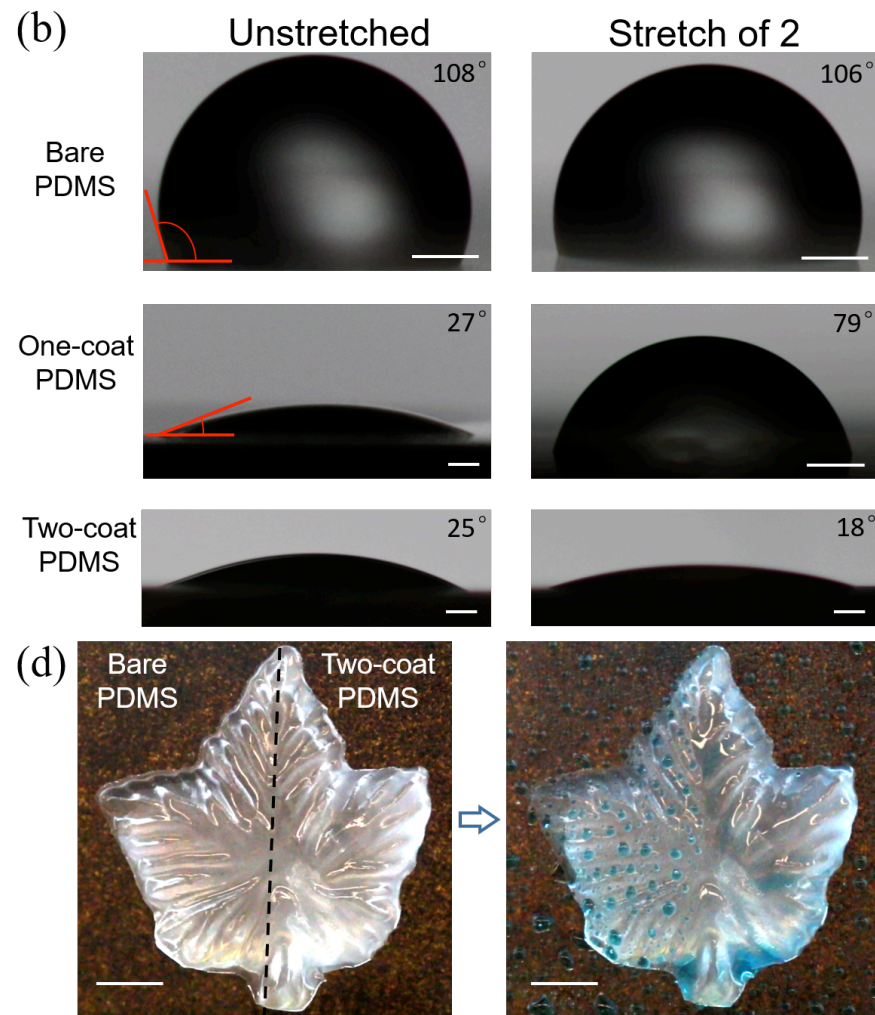
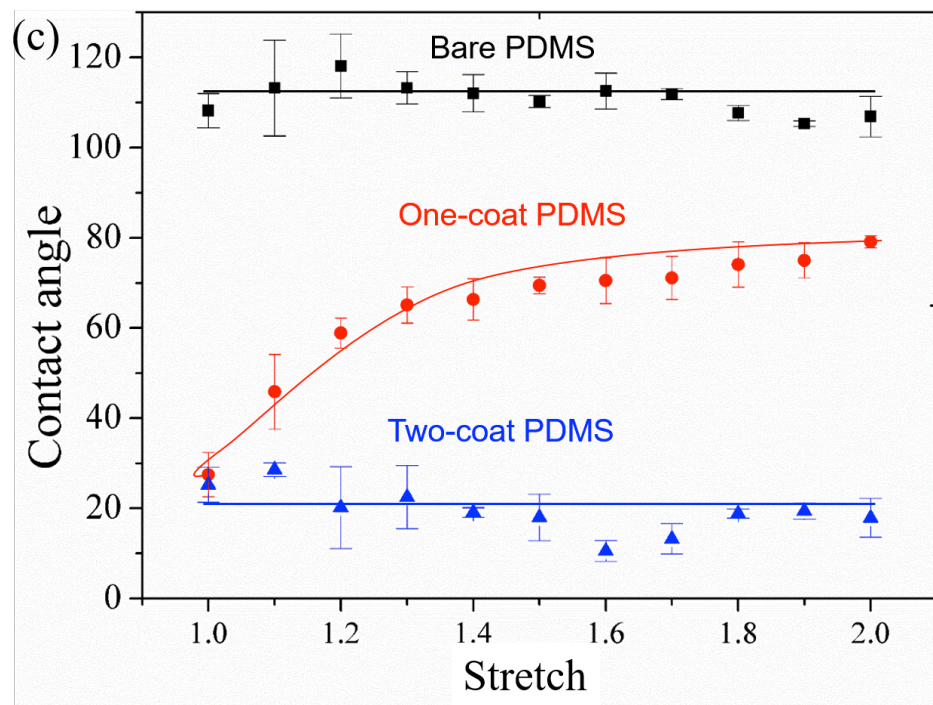
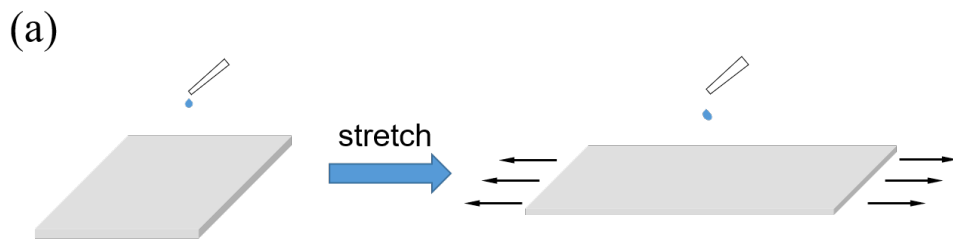
Strong adhesion



Easy detach

Topological lithography





Summary

- Function by integration
- Adhesion by molecular bonds or stitches
- Hydrogel paint
- Topological adhesion
- Photodetachable adhesion
- Topological lithography