Low-voltage-driven hydrogel actuator using hydrophobic interaction between poly(ethylene glycol) and iodine

([1]*Graduate School of Science, Department of Chemistry, The University of Tokyo*)
○Hongyao Zhou,[1] Teppei Yamada[1]
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Biological muscle responds to the electric stimuli emitted from the nerve cells, and the voltage across the cell membrane is generated by opening/closing of numerous ion channels. Here we present a supramolecular hydrogel actuator which can reversibly swell and shrink in response to external voltage and electrochemical production of redox-active ions. The hydrogel is composed of crosslinked polyethylene glycol (PEG), which selectively captures triiodide anion (I_3^-). [1,2] When PEG hydrogel adsorbs I_3^-, the hydrogel shrinks because of formation of the hydrophobic PEG–iodine complex, and water is released from the hydrogel (**Figure 1a**).

The hydrophobicity/hydrophilicity of the I_3^-/I^- redox pair can be reversibly switched by applying a small external voltage (< 1 V). The volume and rheology of the hydrogel can be controlled by applying an external current *in situ* (**Figure 1b**). The storage modulus of the gel decreased when I_3^- was reduced to I^- anion (a softer gel), and the value increased again when I^- was oxidized back to I_3^- anion (a harder gel). Further, a force was produced from the hydrogel when the hydrogel swells. PEG–iodine hydrogel actuator only requires a small voltage (0.5 V), and the applications into biomimetic soft robots are highly anticipated.

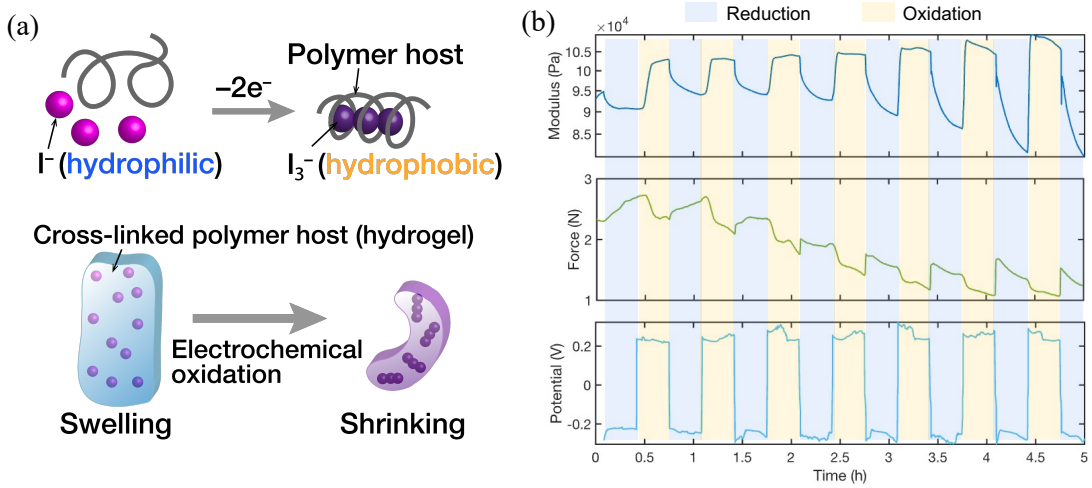

Figure 1. (a) Swelling/shrinking mechanism of PEG–iodine hydrogel actuator (b) In-situ measurement of rheology of the hydrogel under electrochemical cycles at a constant current (0.5 mA cm^{-2}). A force normal to the electrode was generated at the reduction (swelling) step.

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