Supplementary Information

Fig. S1. Microfabrication of the microfluidic device. (a) Soft lithography process, and (b) assembly of the electroactive hydrogel pump. The pump consists of four parts: PDMS channel, EAP hydrogel, silver wires, and coverslip.

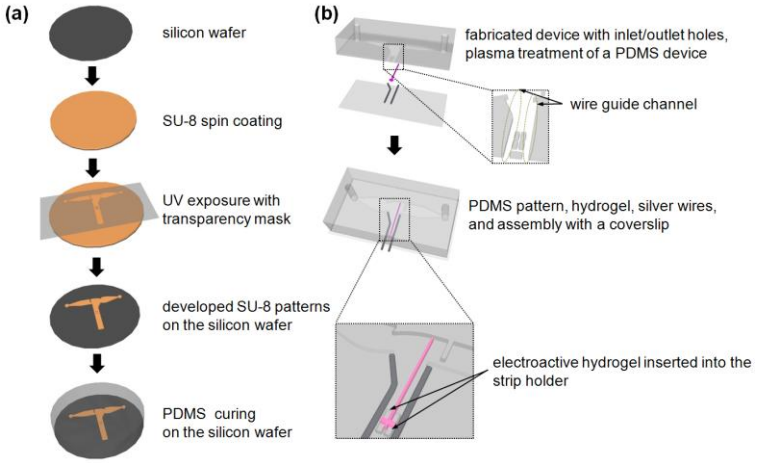

Fig. S2. (a) Method of measuring the micropump power consumption. We used a very small resistance, (R_1: 267 Ω); therefore R_1 did not affect the current profile. (b) Long-term operation test with a standard AA 1.5 V battery.

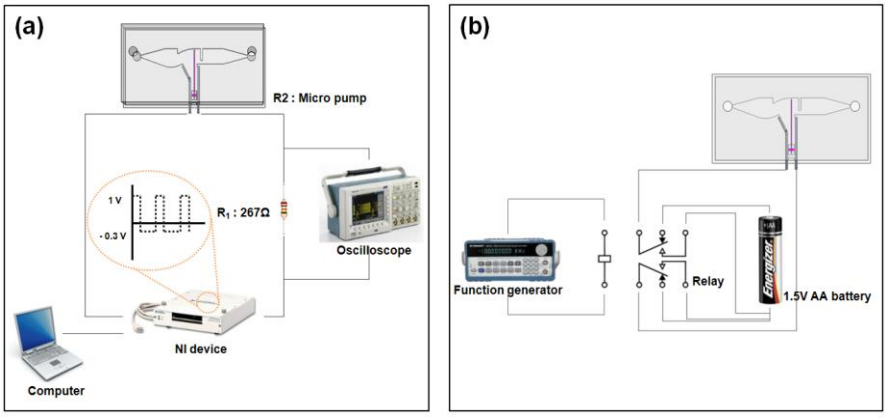

Fig. S3. The three geometries used to model the pressure distribution of the electrically-driven hydrogel valveless micropump: (a) model 1, (b) model 2 (with weir), and (c) model 3 (with weir and stop post).

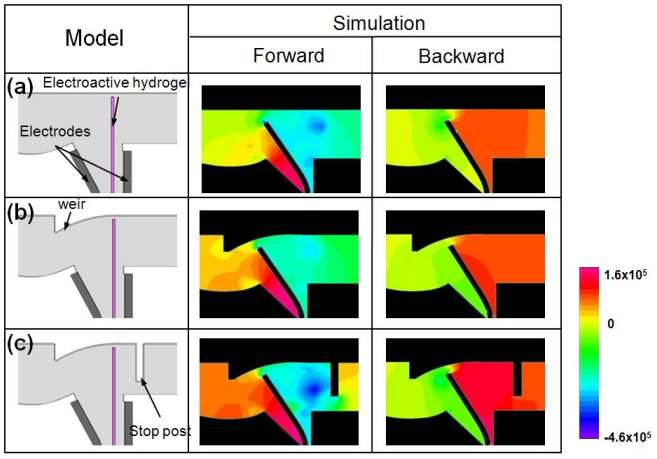

Fig. S4. Graph showing the time evolution of the actuation stroke, an indicator of electroactive hydrogel durability. The strip dimensions were 4 mm in length, 50 μm in width, and 300 μm in thickness. The error bars indicate the standard deviation from 6 trials.

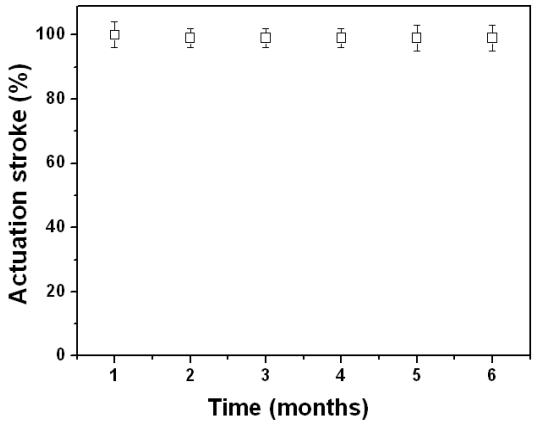

Fig. S5. Morphological changes of the MCF-7 human breast cancer cell line after anti-cancer drug treatment. MCF-7 cells were treated with adriamycin (50 μg/mL) for 24 h, and the morphological changes in the cells were monitored using an inverted microscope. (a) No adriamycin treatment group and (b) adriamycin-treated group.

The majority of cells were floating and had irregular cell walls. Some cell debris was present in the medium. The scale bars indicate 500 µm.

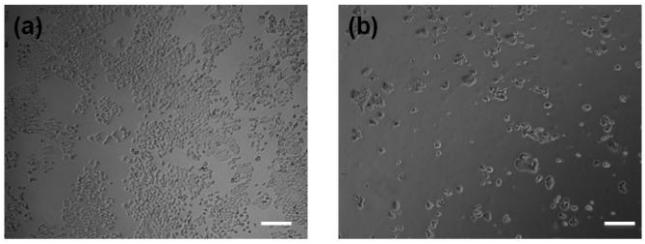

Fig. S6. Graph showing the energy consumption. Voltage as a function of time during continuous operation of the electroactive hydrogel micropump (using a standard 1.5 V AA battery). The error bars indicate the standard deviation (n=10).

Comment [nineone1]: Referee #3 10 question

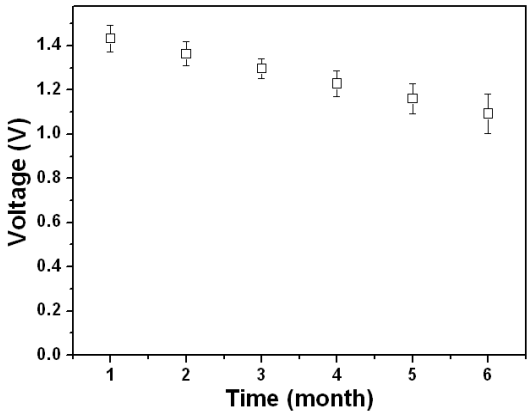

Fig. S7. The time-varying force condition is imposed to the solid domain.

Comment [nineone2]: Referee #3 2 question

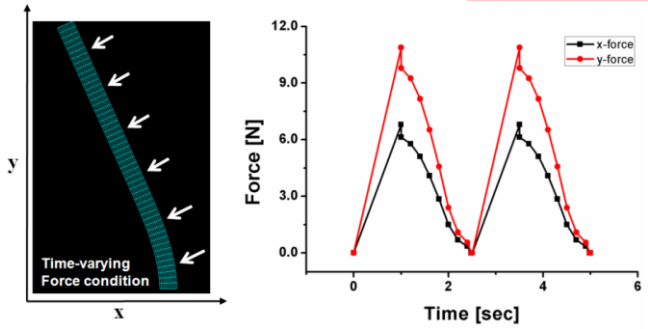

Fig. S8. The bending angle of 4-HBA hydrogel as a function NaCl concentration at 9 V constant voltage. The strip dimensions were 4 mm in length, 50 μm in width, and 300 μm in thickness. The error bars indicate the standard deviation (n=5).

Comment [nineone3]: Refree #1 6 question

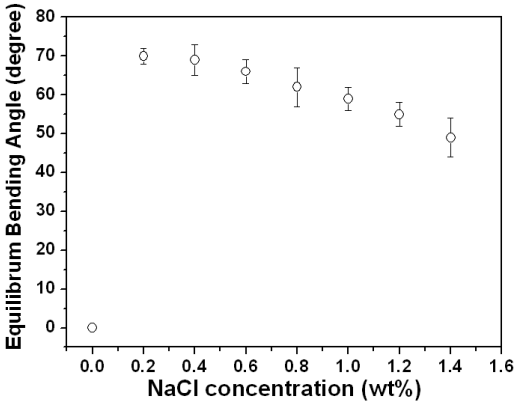

Fig. S9. The pump driving system integrated with 1.5V button-type battery (alkaline, Fuji yama, Japan) and control system, and the proposed pumping system worked well with small button-type battery.