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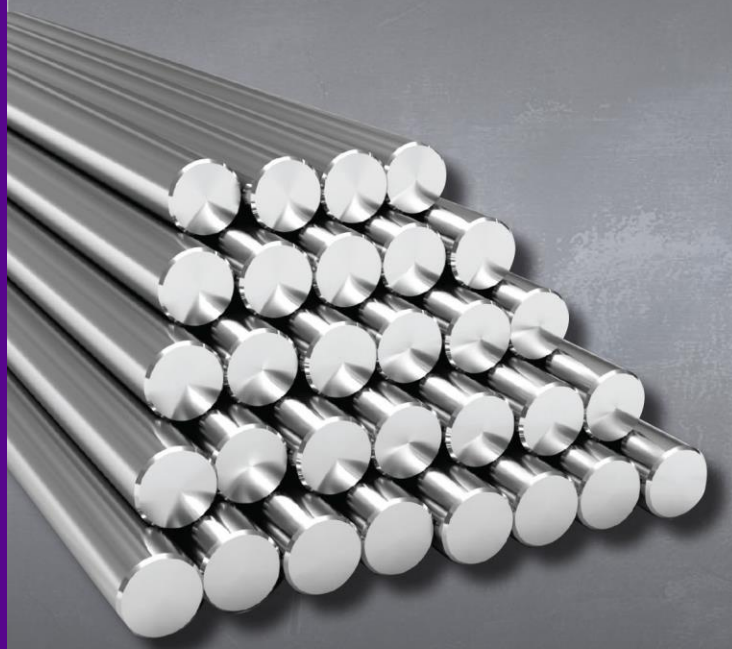
259th OMICS International Conferences

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International Conference on

Smart Materials & Structures

June 15 -17, 2015 Las Vegas, USA



Exploring the Fusion of Intelligence with Materials

University of Bolton

NSU NOVA SOUTHEASTERN UNIVERSITY

Operated by: Editors- Journal of Material Sciences & Engineering, Journal of Vortex Science and Technology and Journal of Nanomaterials & Molecular Nanotechnology

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Photogated motility in smart actuators with dual response

Speaker: Lidong Zhang

Postdoc in Prof. Naumov group
in New York University

International Conference and Expo on Smart materials & Structures, June 15-17, Las Vegas, USA

Environmental contamination





Image source: https://saferenvironment.wordpress.com/

Extensive reduction of pollution needed to save environment:

Coal-fired power plants are the largest source of pollution

The pollution produces severely damage human health and quality of life.

Air pollution is a prime contributor to global warming.

Cleaning up these plants and finding cleaner, alternative energy sources is the overall objective to achieving clean, healthy air in every country.

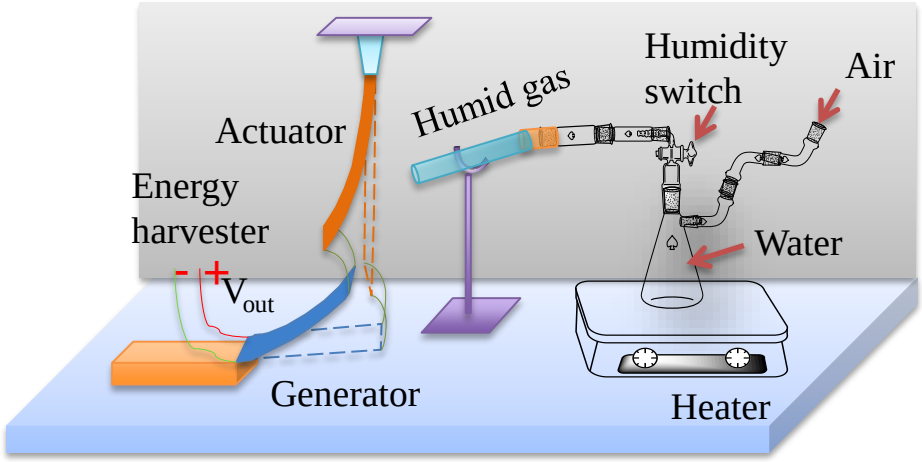
Exploitation of clean energy from humidity

Goal:

- Development of a new material for conversion of potential energy of humidity to mechanical work
- Generation of electricity without contamination of the environment



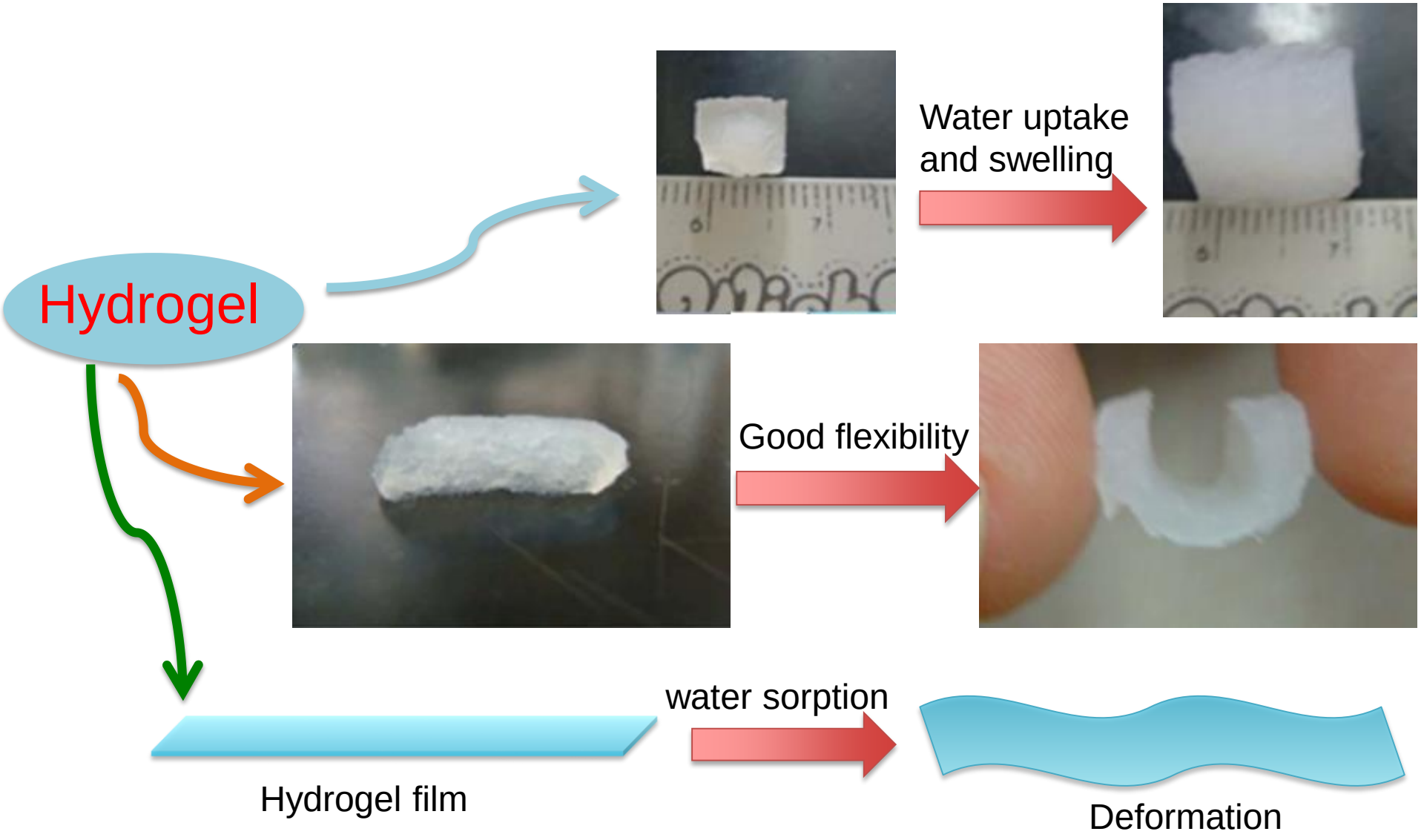
Video source: https://www.youtube.com/watch?v=TOJG5mF6OLs



Device for generation of electricity

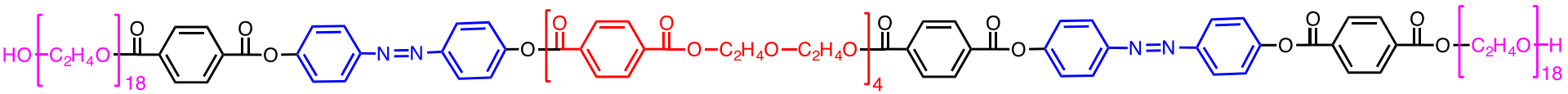
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Research background



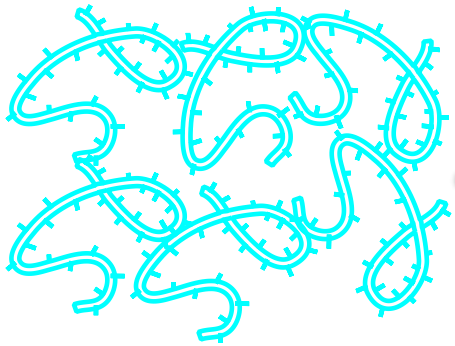
Lidong Zhang, *et al*. *Polym. Chem*., 2013, **4**, 1084; Lidong Zhang, *et al*. *Macromol. Biosci*., 2014, **14**, 401; Lidong Zhang, *et al*. *RSC Adv*., 2013, **3**, 4692

Preparation of smart hybrid film



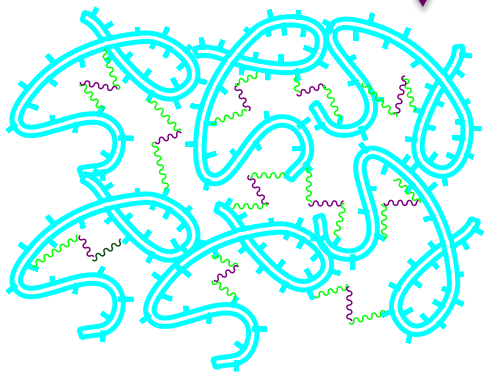


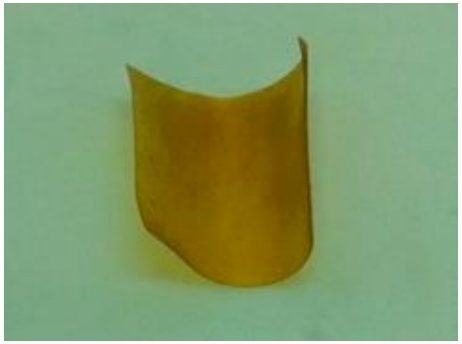
Photosensitive segment Flexible segment Photosensitive segment



Hydrogel (agarose)

Hybridization



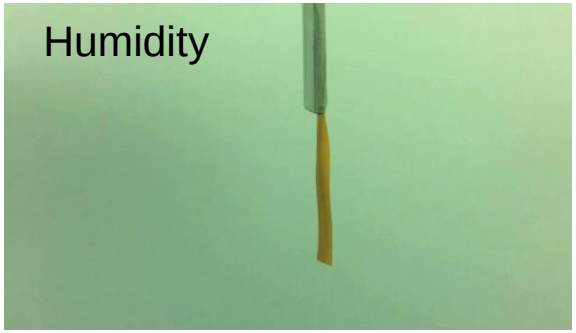


Humidity-, and light-sensitive film

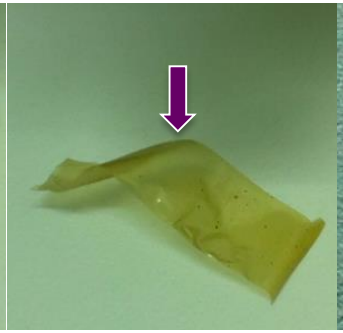
Lidong Zhang. *et al. Nature Commun*., 2015, **6**, 7429.

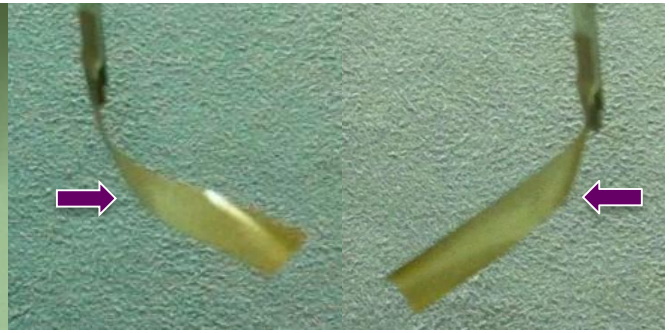
Energy conversion from humidity

The humidity-driven bending is directional

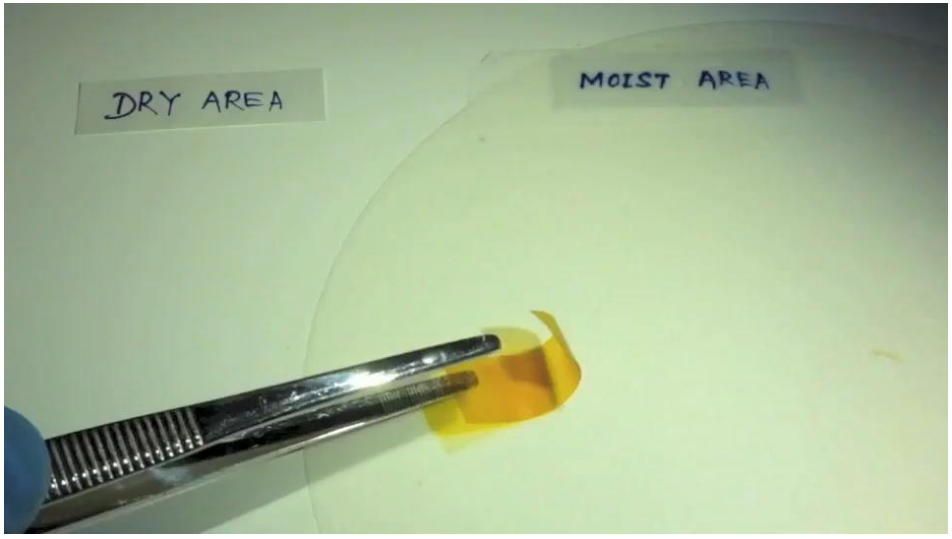




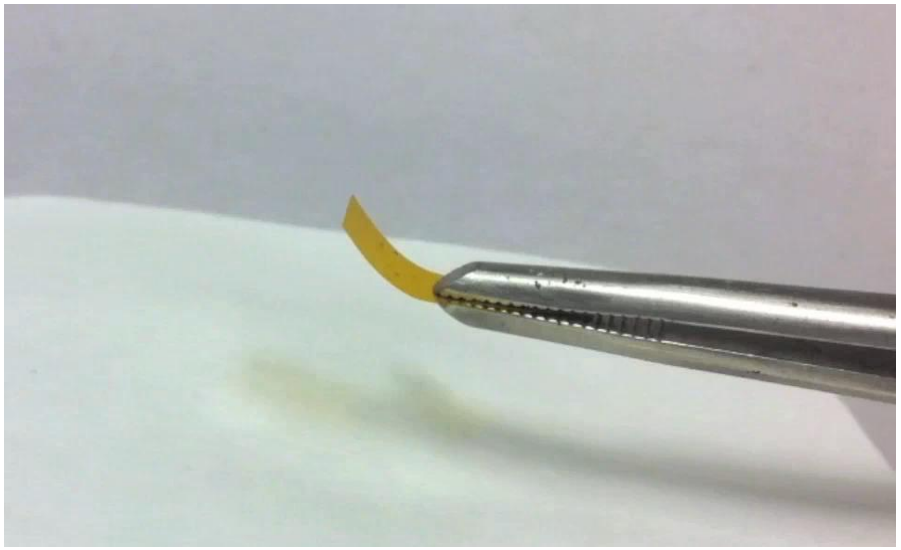




Only water as energy source

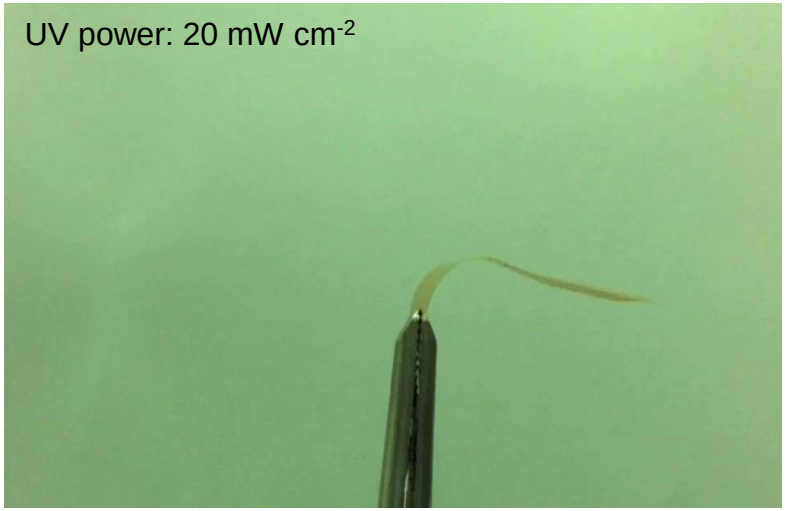


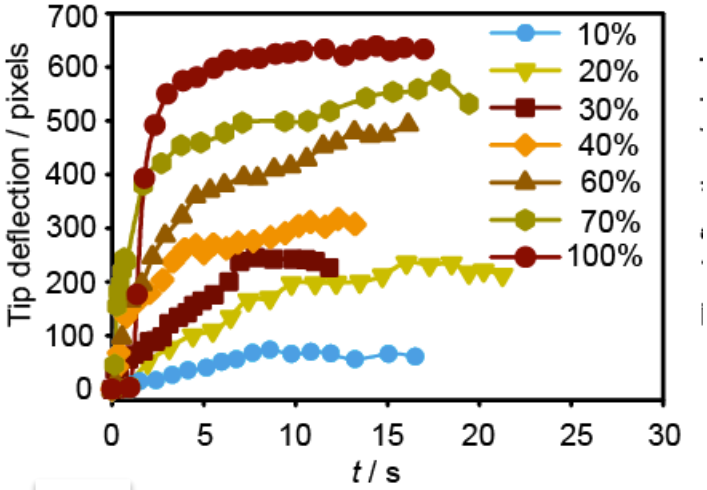
Bending cycle testing

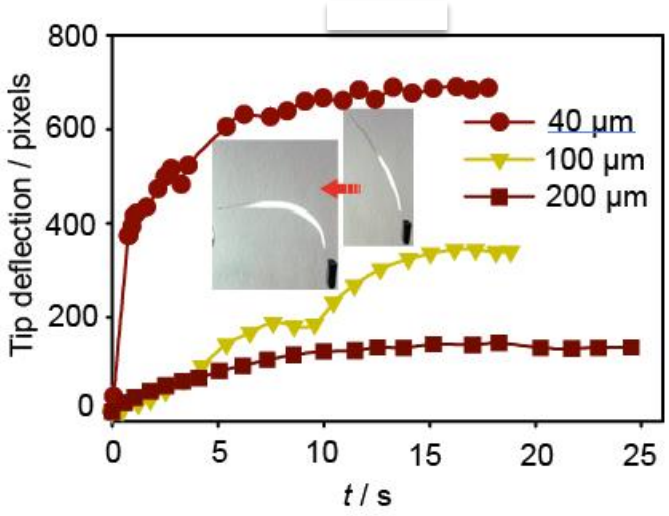


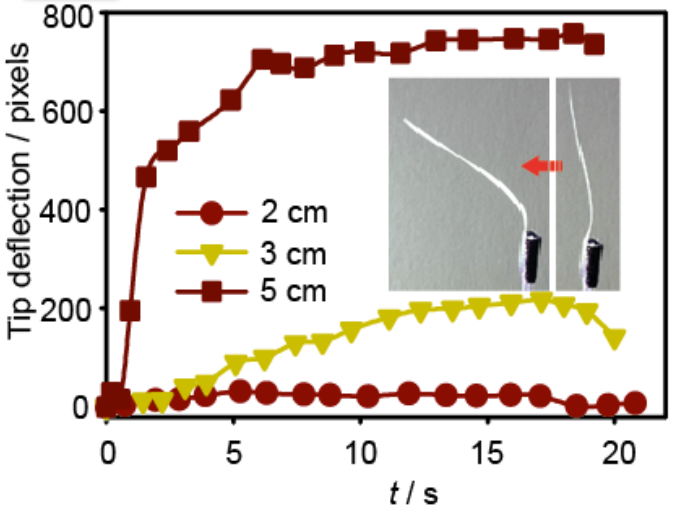
Conversion of light and heat energy

Light-driven bending is non-directional

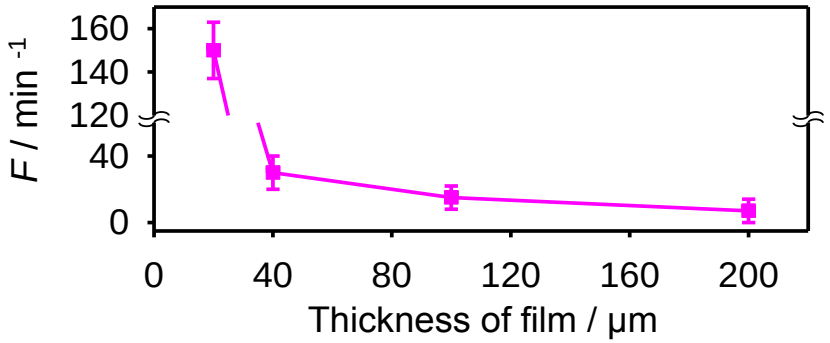


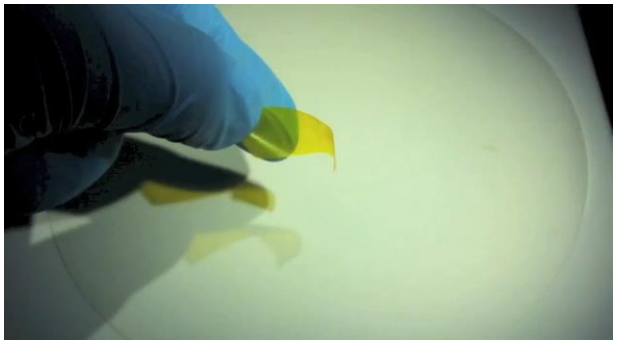


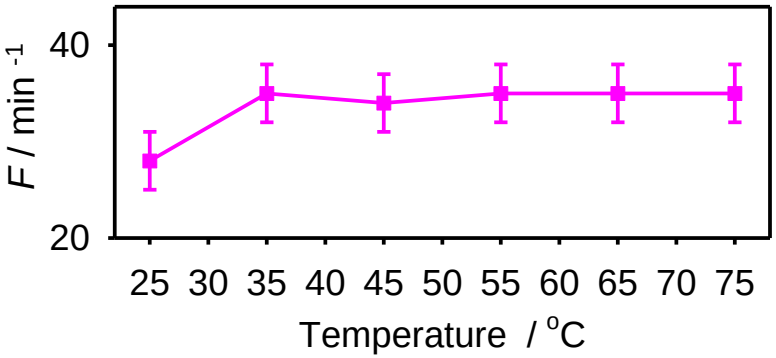


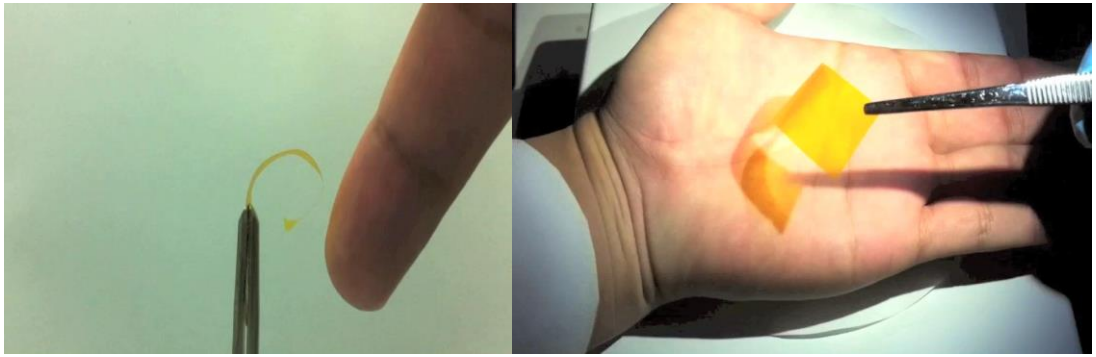


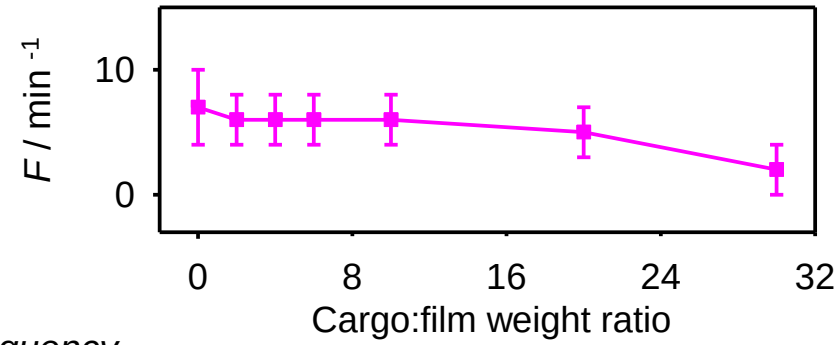
Factors that affect motility of films









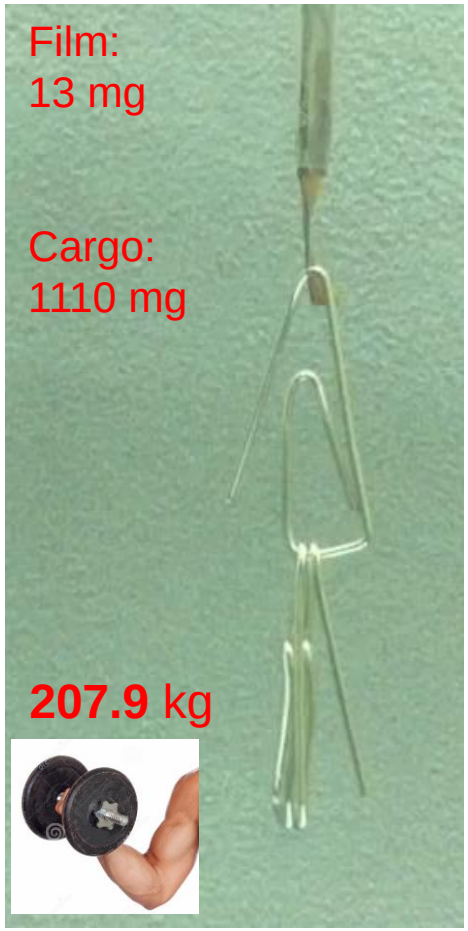


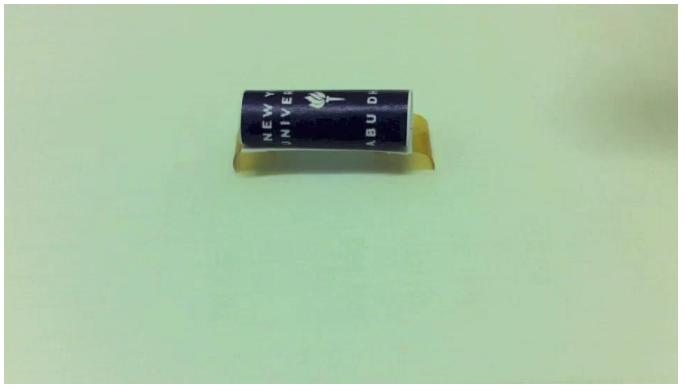


F = Frequency

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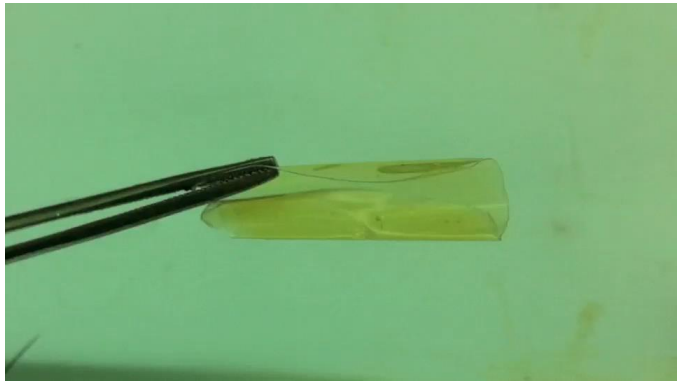
Humidity-driven crane and soft robots





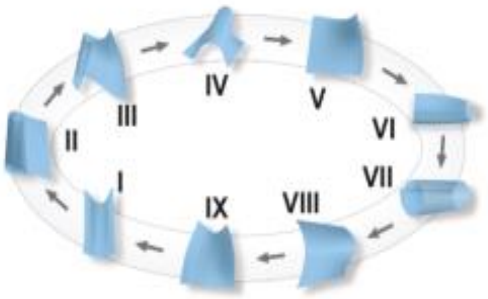


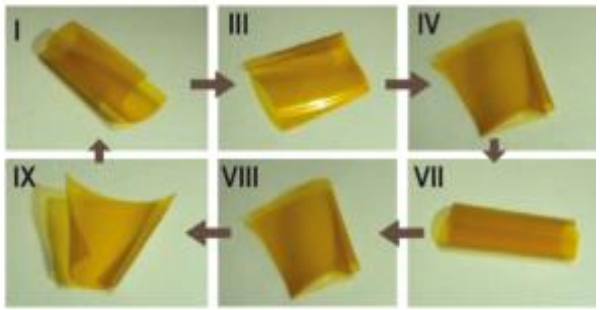


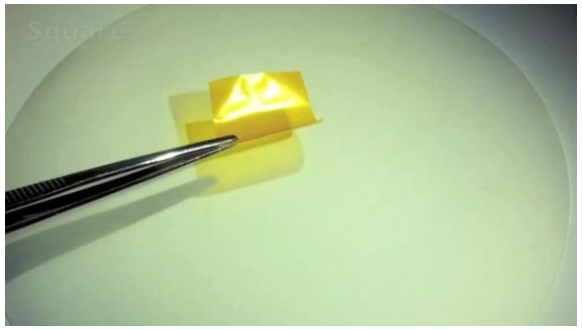


Kinematics and mechanism of locomotion

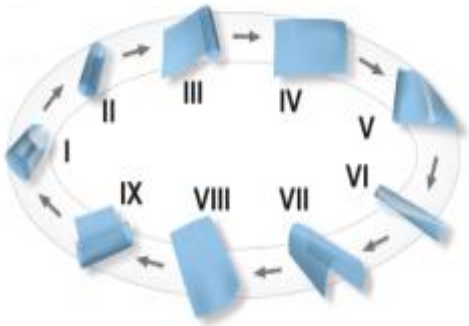
Square

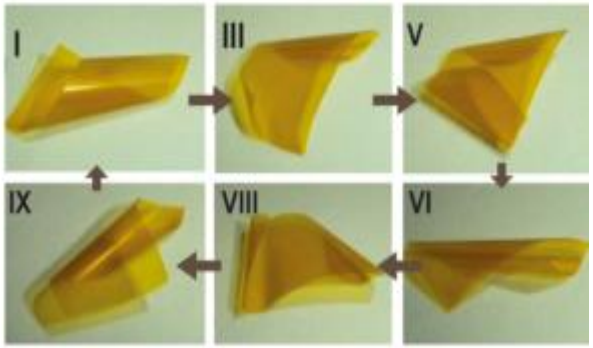






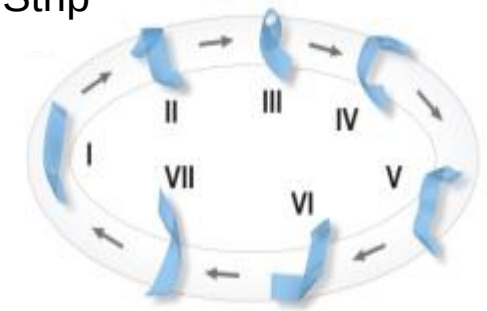
Rectangle

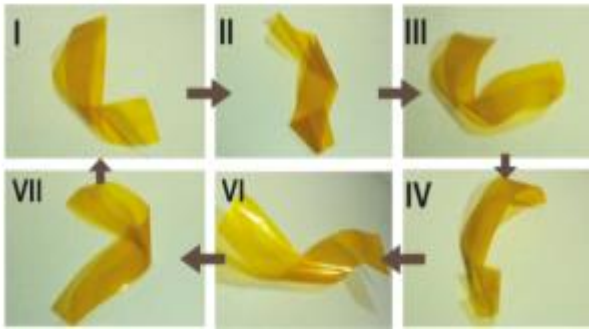


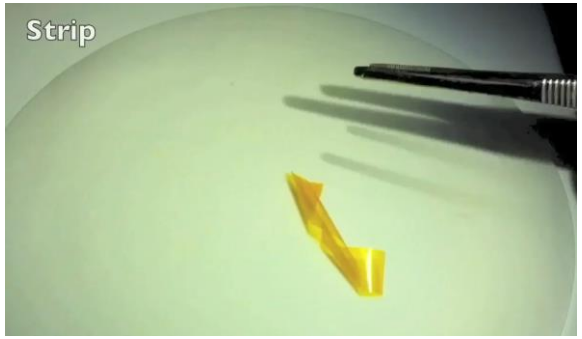




Strip







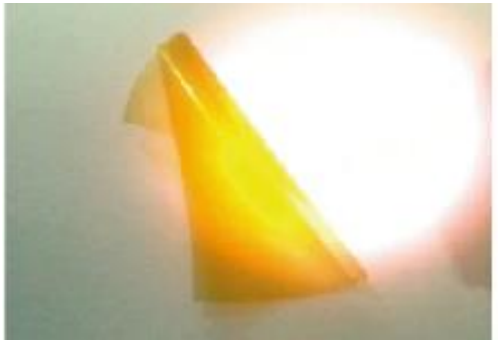
Photomodulated humidity-driven motion

Film on a moist paper

UV light off
Motion starts



UV light on
Motion stops



Motion starts

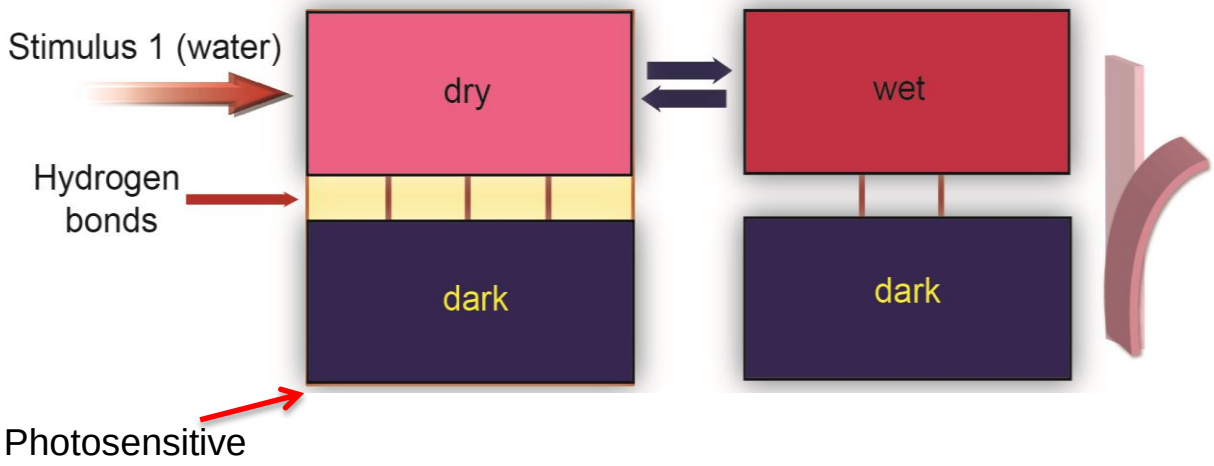
UV light off

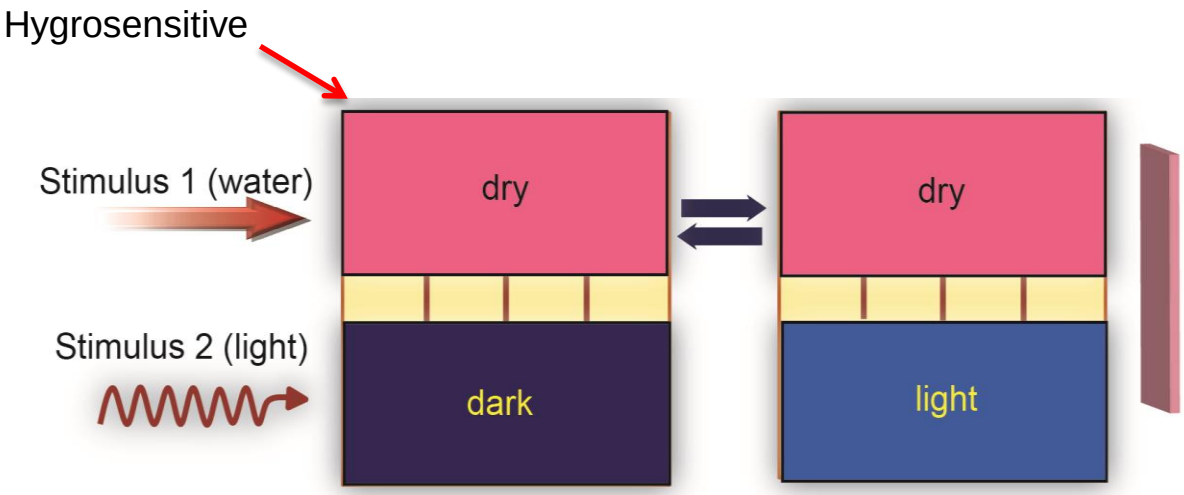


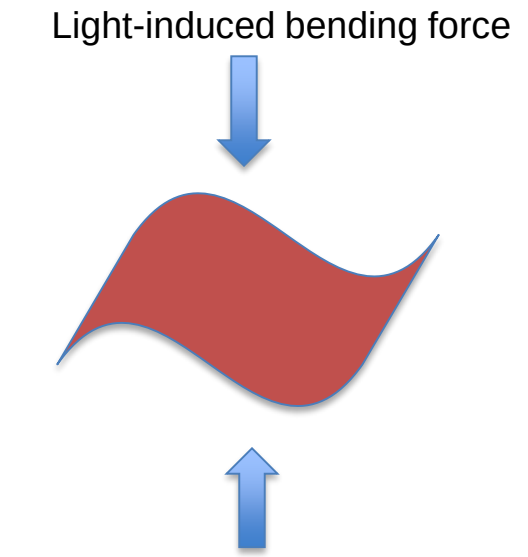




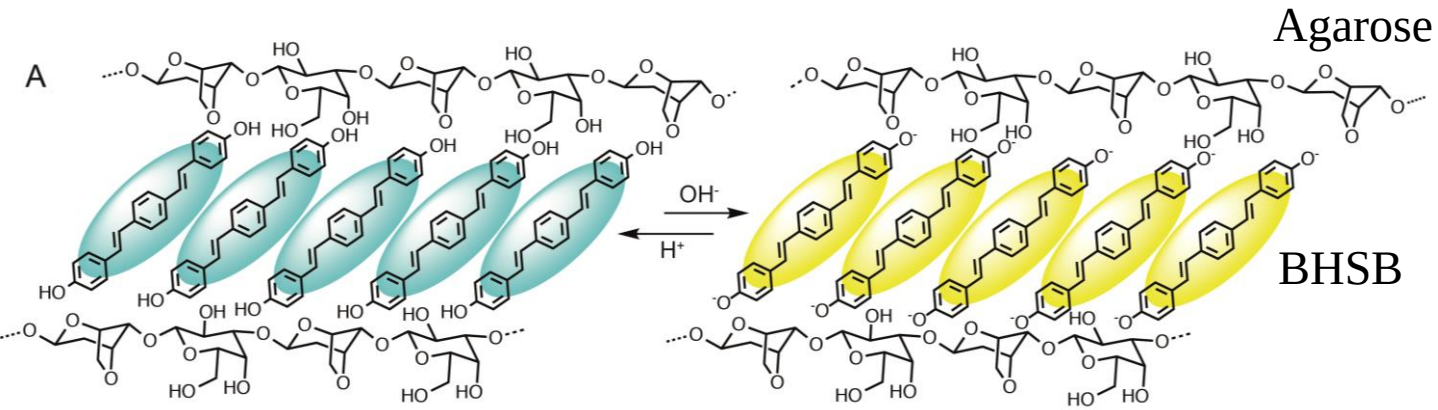
Mechanism of photomodulated motion

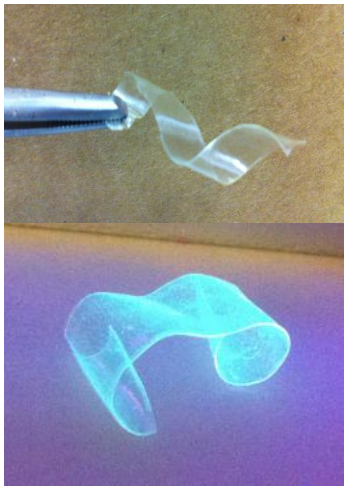






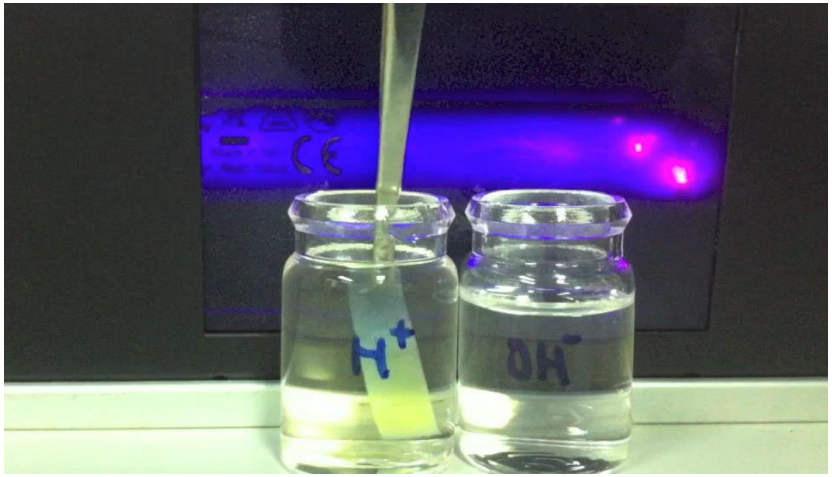
pH-induced color change of the film



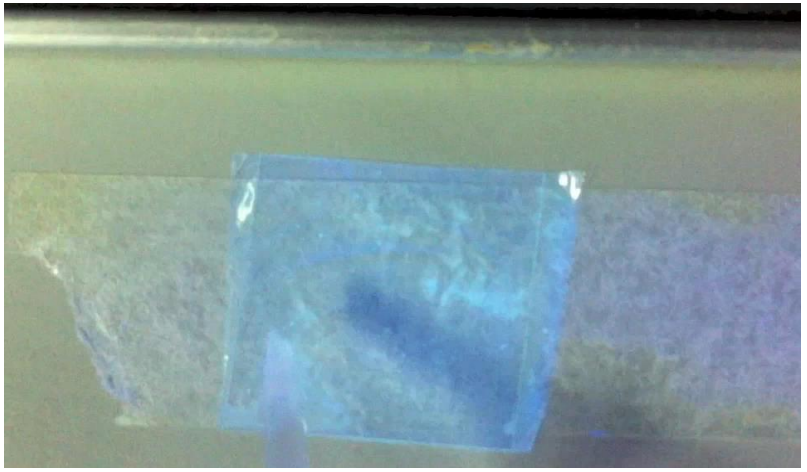


BHSB (1,4-bis(*p*-hydroxystyryl)benzene) is a fluorescent molecule strongly responsive to pH color change.

Agarose is a gel material strongly responsive to humidity with great change in shape.



Color switch between blue and yellow

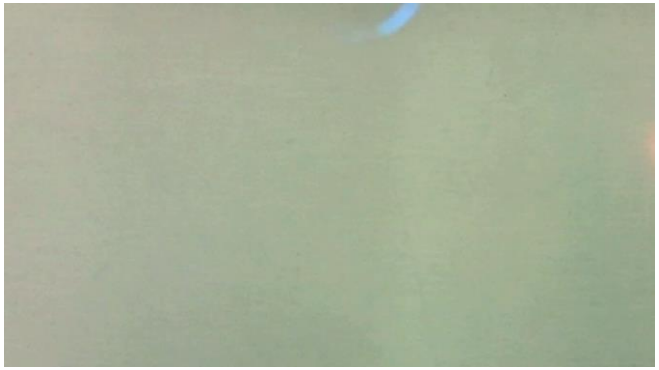


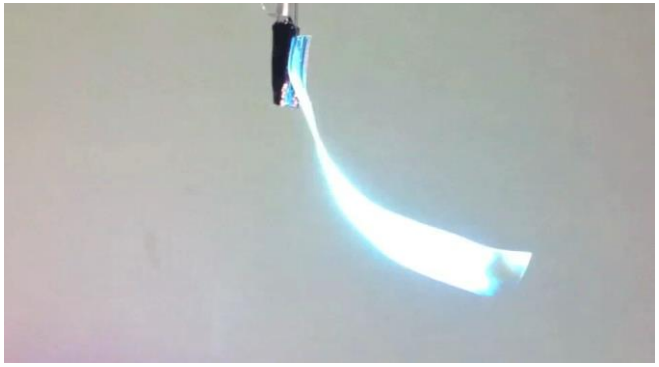
Alkali-solution as ink for writing

Light-triggered motility of the film

https://www.youtube.com/watch?v=g8mr0R3ibPU

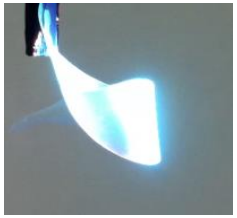


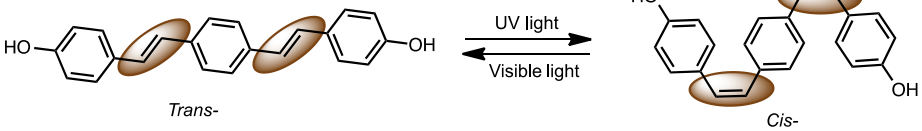


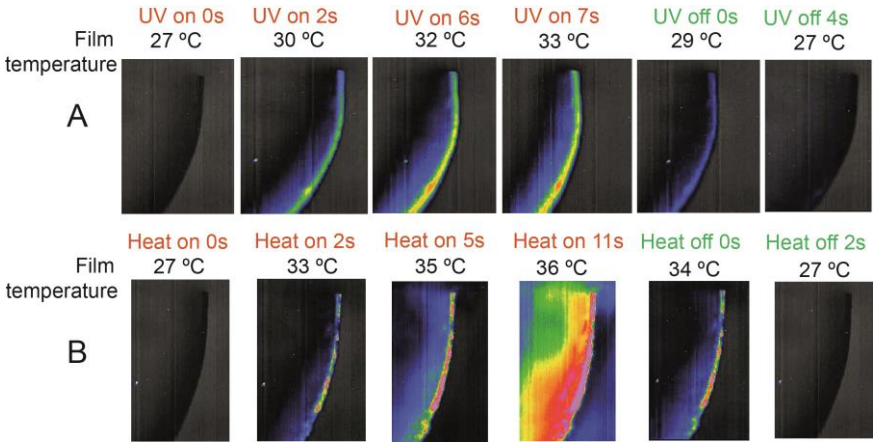




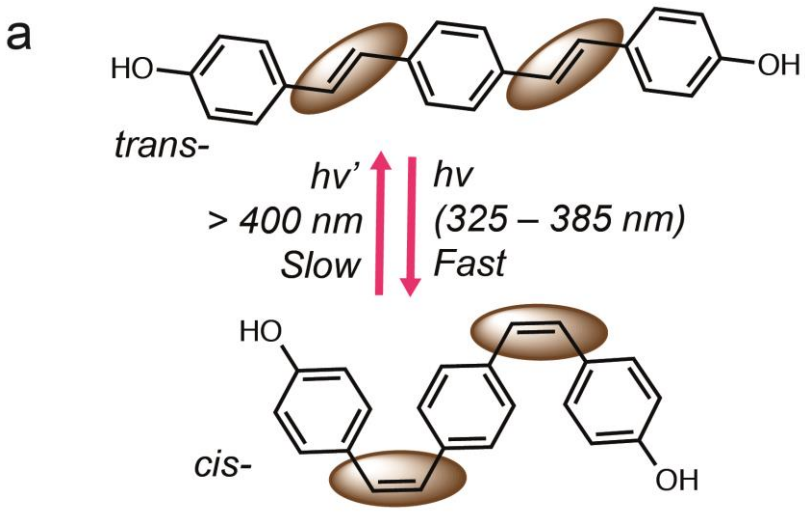
UV light

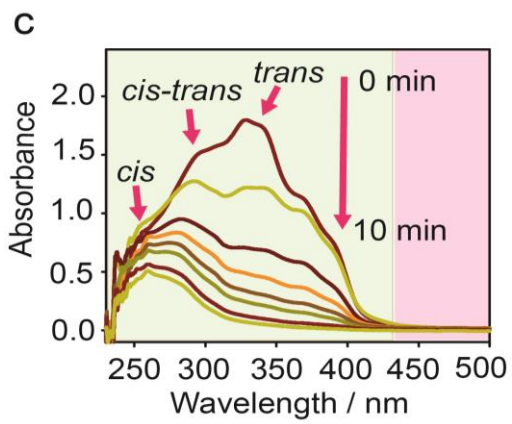




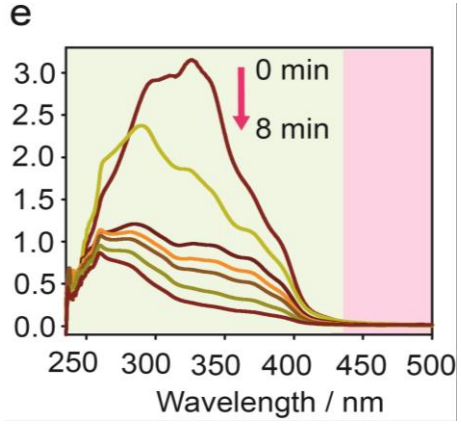


Mechanism of the response to light

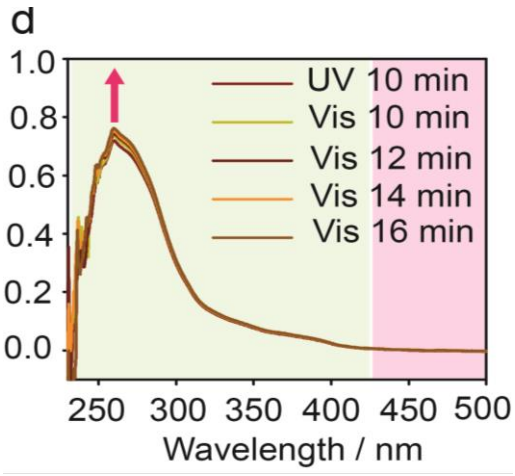




trans*-to-*cis isomerization in dry film



trans*-to-*cis isomerization in DMF solution



cis*-to-*trans isomerization in dry film

(c) Time-dependent UV–Vis spectra of the film recorded during continuous UV irradiation.

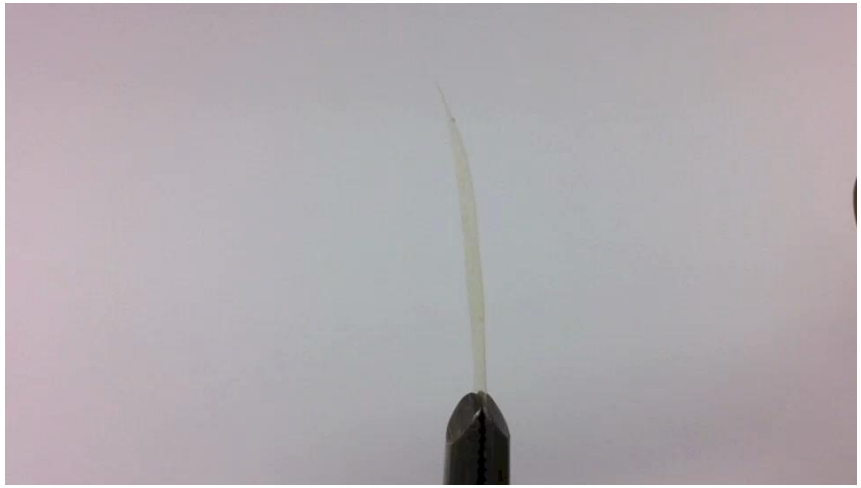
(d) Evolution of the UV–Vis spectrum recorded after the film was irradiated with UV light for 10 minutes ('UV') and then kept in visible light ('Vis').

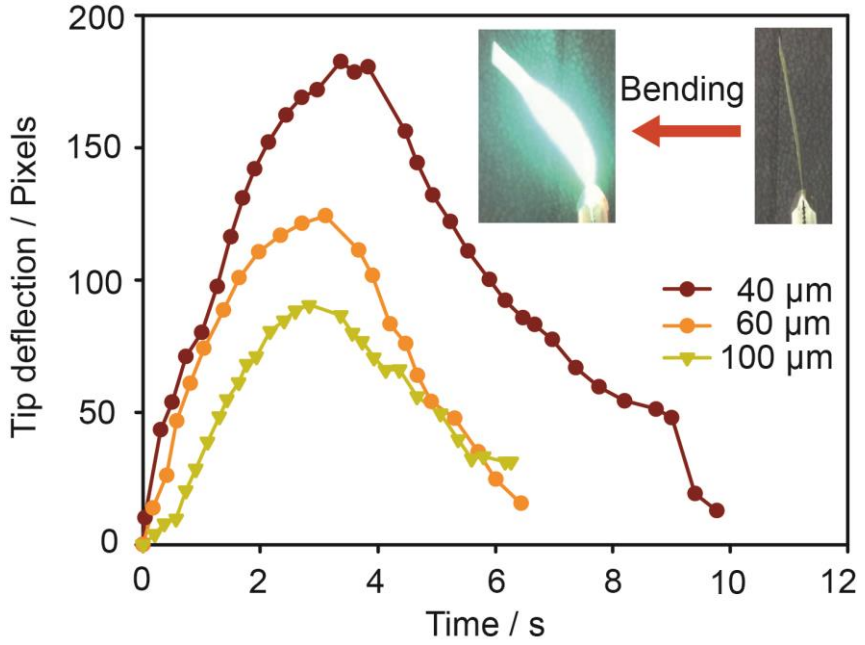
(e) Time-dependent UV–Vis spectra of BHSB irradiated with UV light in DMF.

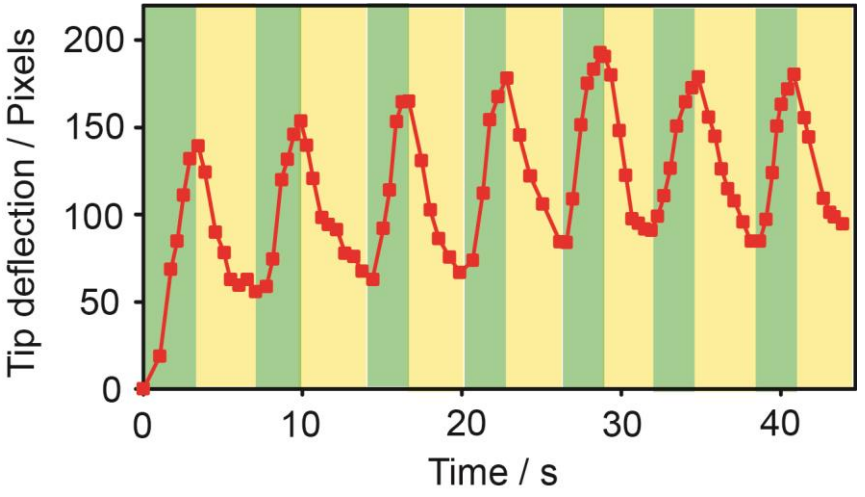
Characterization of motility



Repetition of the bending







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Humidity-triggered curling of the film

Simulation of Cucumber tendril



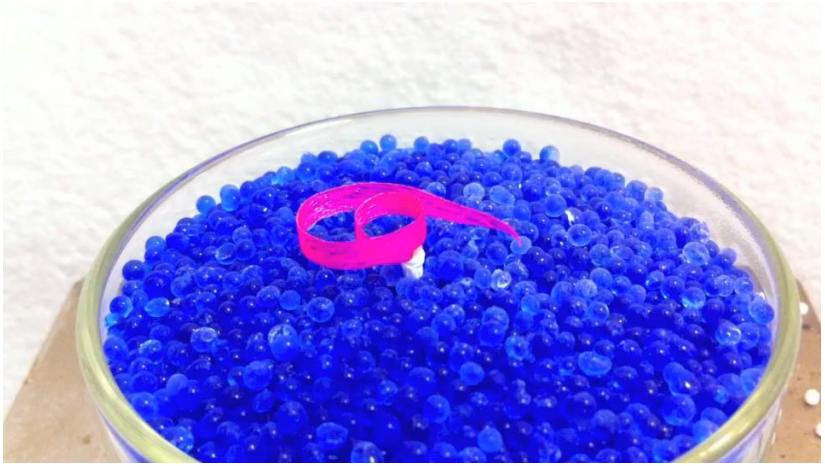
https://www.youtube.com/watch?v=--C0921z9K4



https://www.youtube.com/watch?v=TOJG5mF6OLs



Simulation of Erodium seed



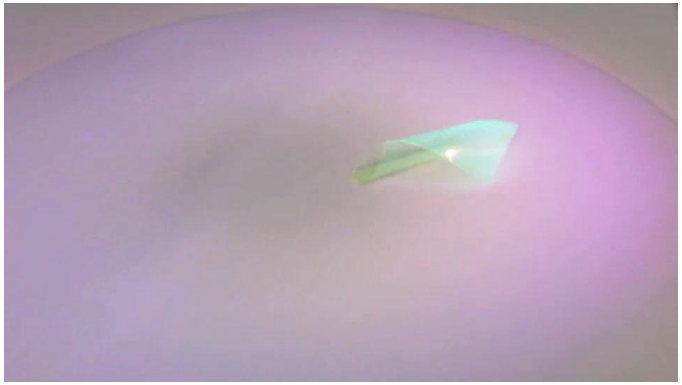
Humidity-triggered motility of the film

Motion without UV light





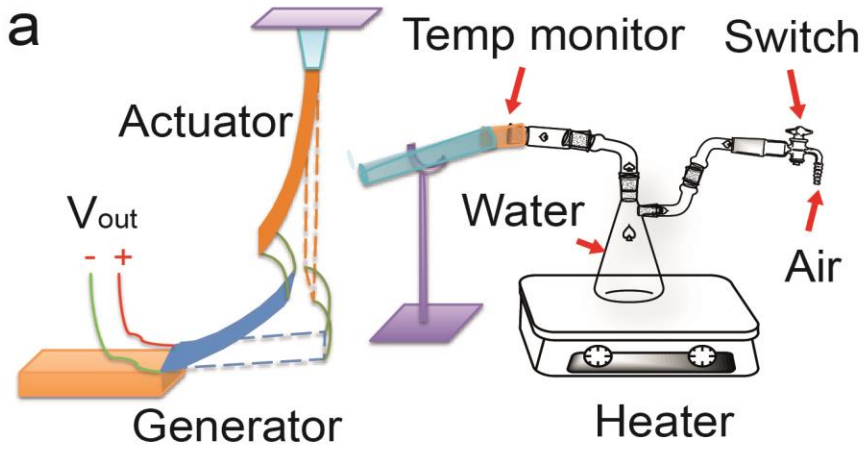
Motion with UV light

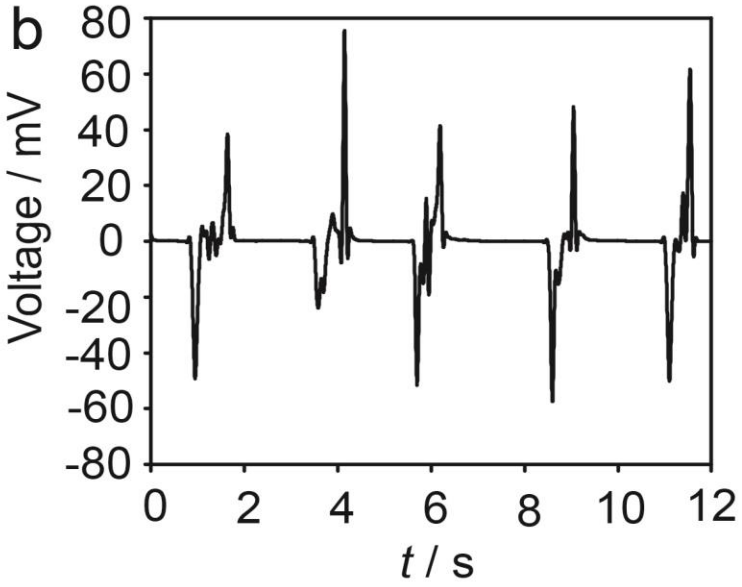


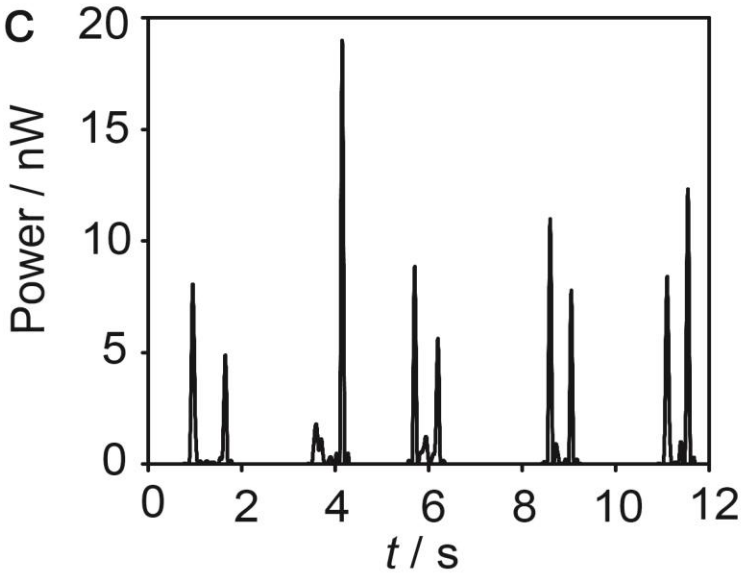


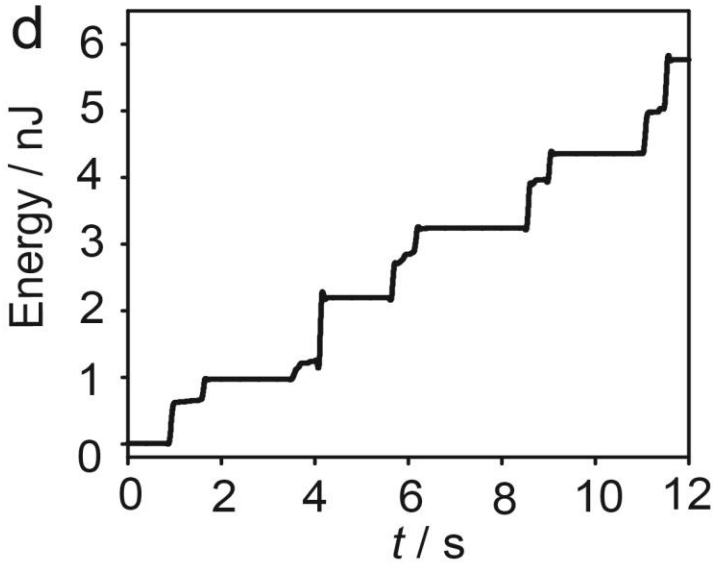
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Application for power device









Conclusions

- The hybrid films strongly respond to humidity, UV light and heat.
- The film is able to convert potential energy of humidity into mechanical work.
- The film can transport cargos when driven by humidity.
- The motion of the film can be modulated by UV light.
- The film can be combined with piezotransducer to generate electricity.

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