Smart Wound Dressing for Infected Wound Healing and Monitoring Applications

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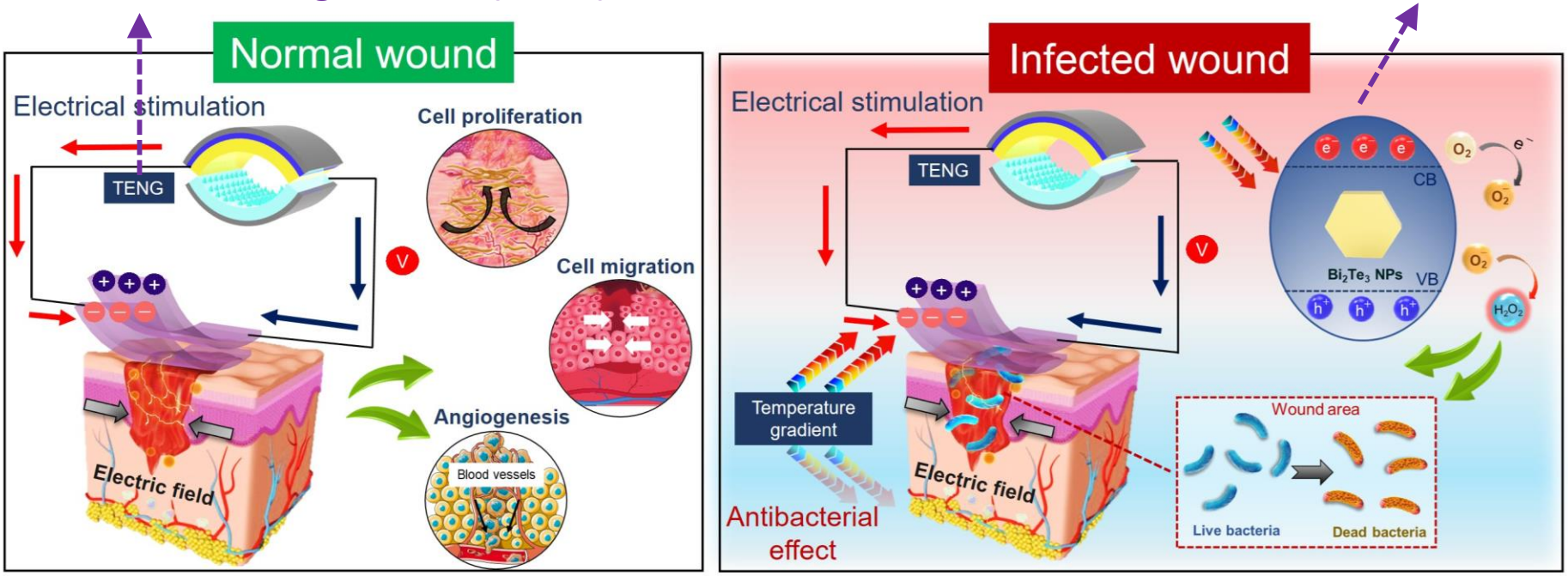
Research Concept

Snigdha R. Barman

Triboelectric nanogenerator (TENG)

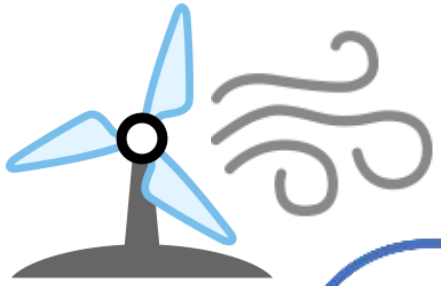
Thermocatalyst



Sci. Adv. **2023**, *9*, eadc8758

Strategies for active antibacterial activity by nanocatalysts

Walking, running



Mechanical vibration

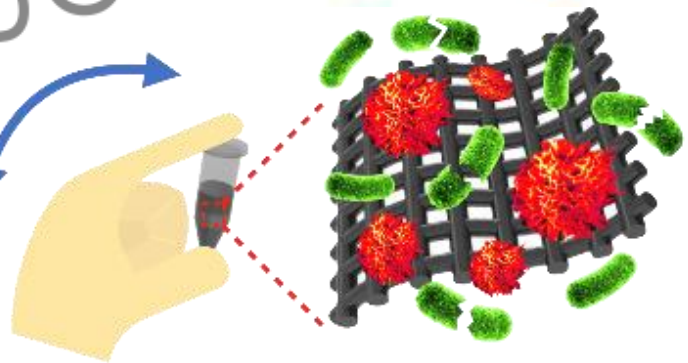
2

Nano Energy 2019, 57, 14

3

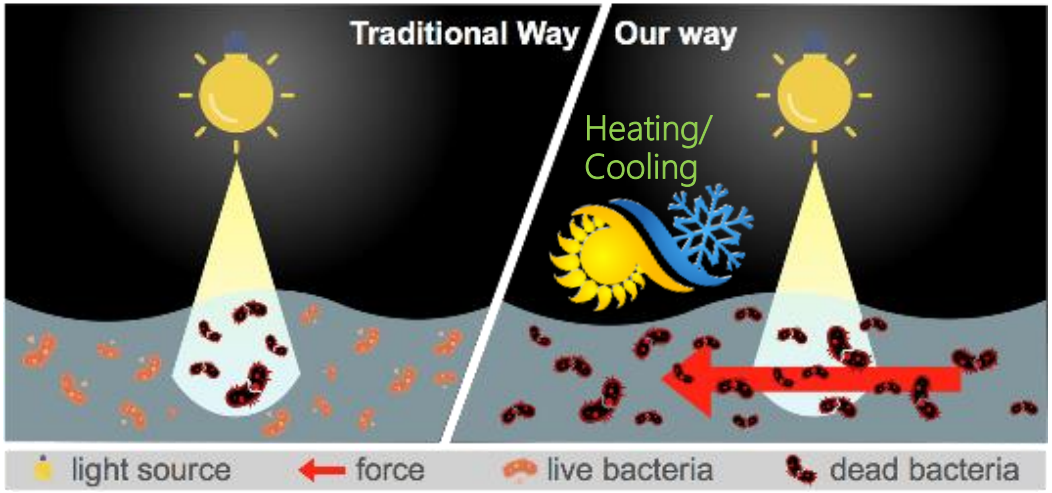
Temperature difference

Nat. Commun. 2021, 12, 180



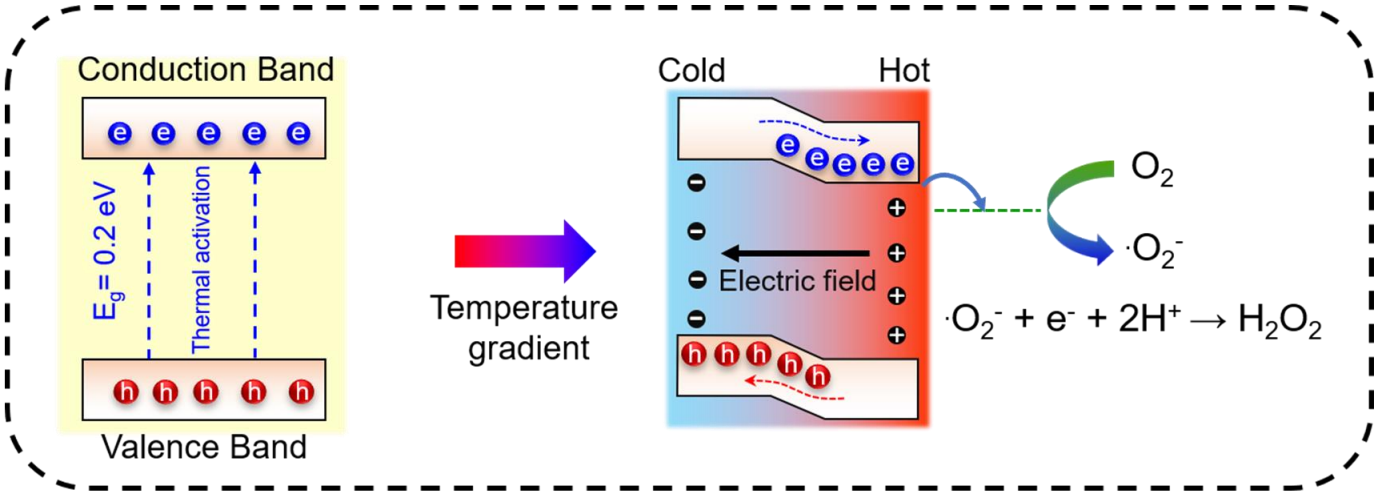
1

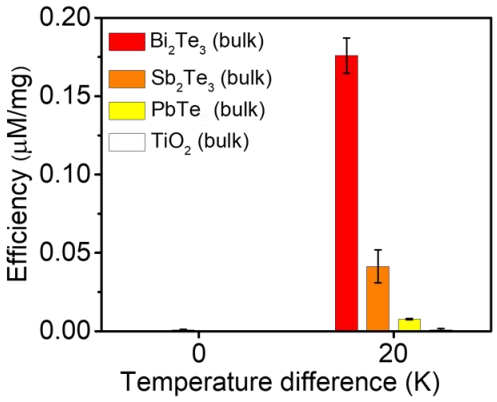
Light irradiation

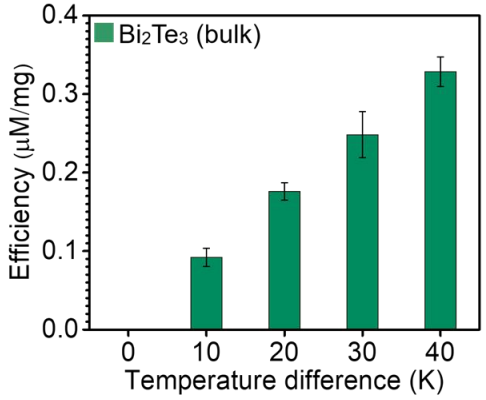


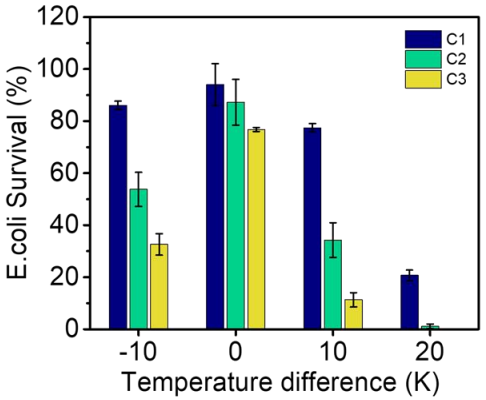
Thermocatalytic H_2O_2 generation by different bulk thermoelectric materials

Yu-Jiung Lin



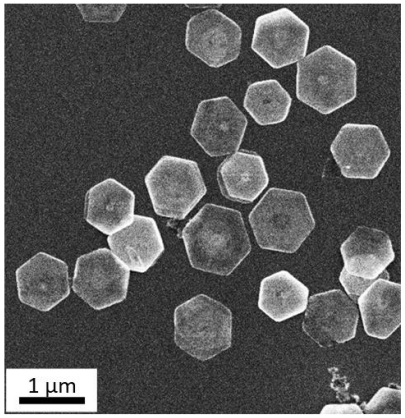


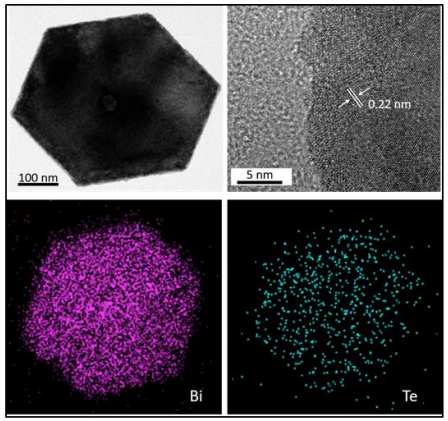


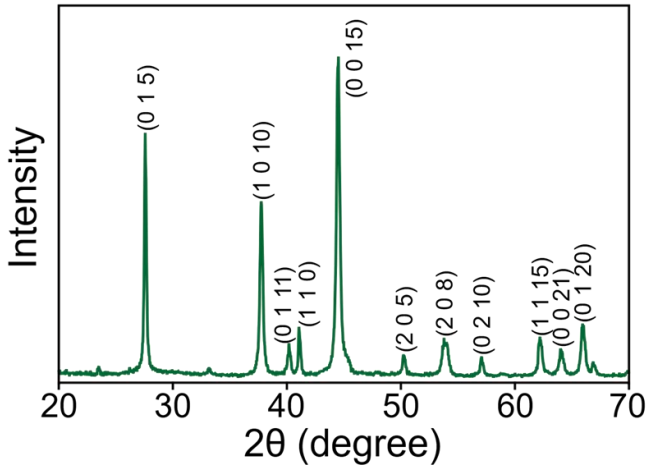


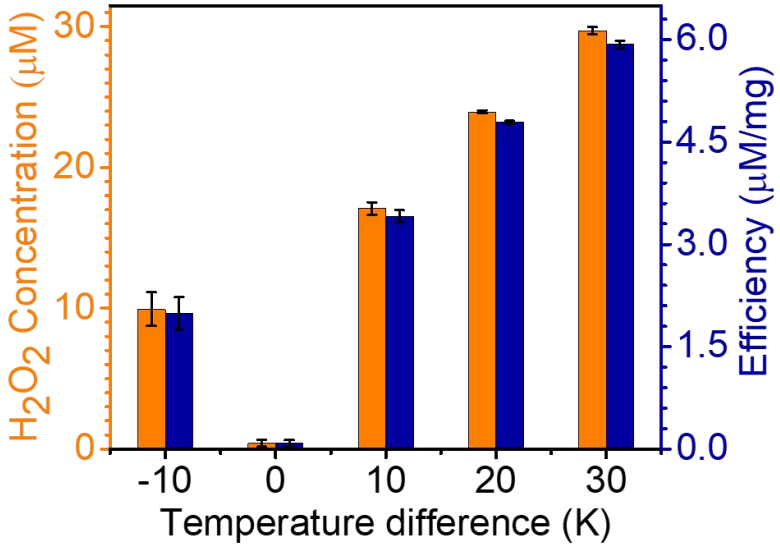
Nat. Commun. **2021**, *12*, 180

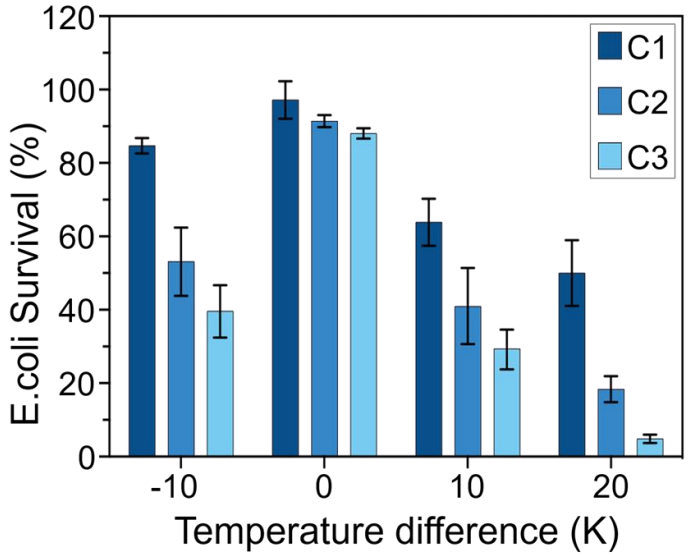
Characterization of Bi_2Te_3 nanoplates (NPs) for H_2O_2 generation and disinfection performance



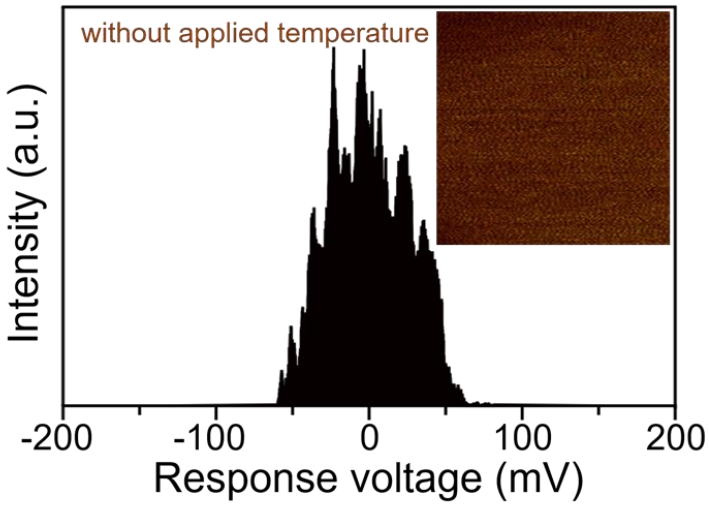


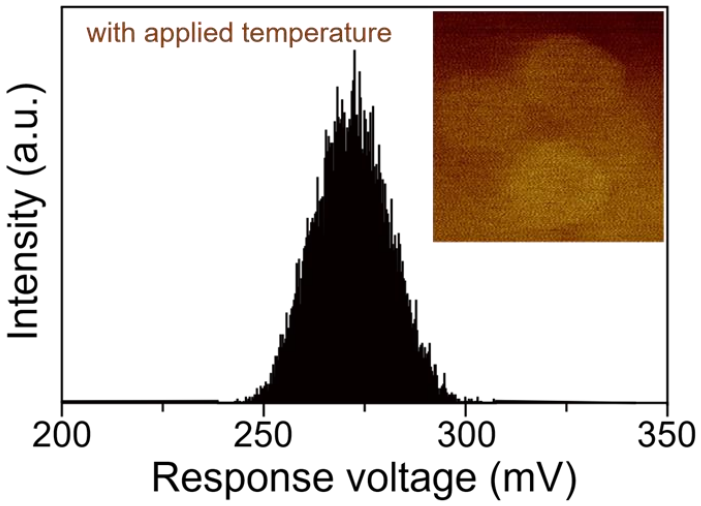


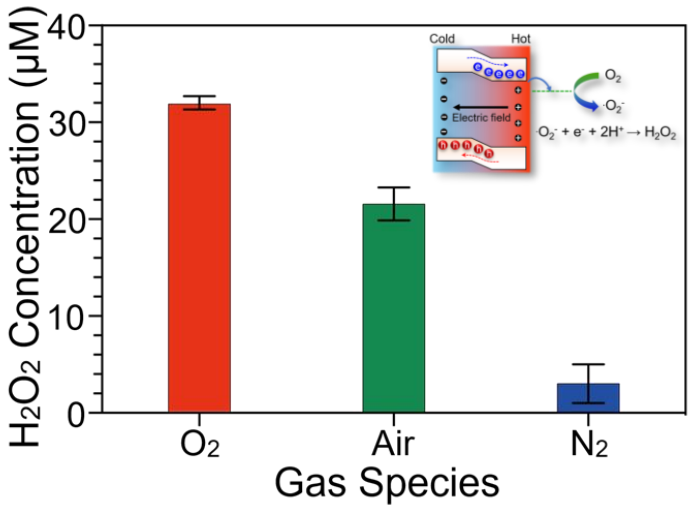


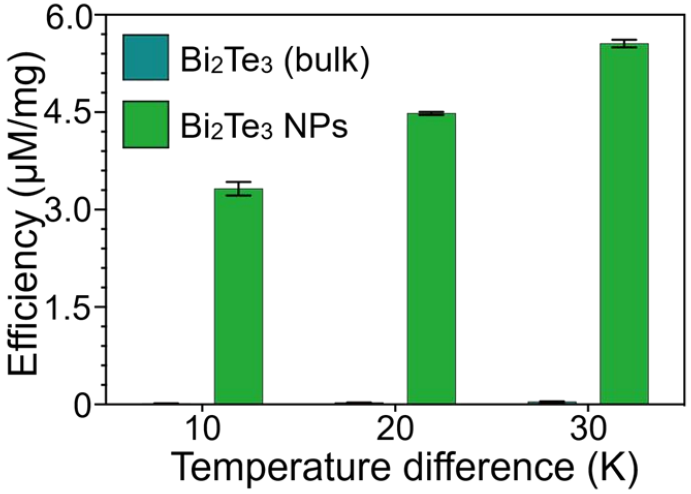


Temperature-induced surface potential evaluation and H_2O_2 generation

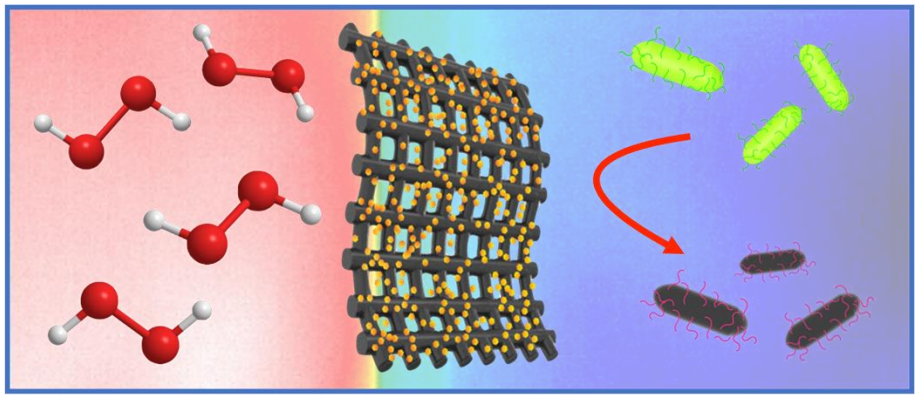


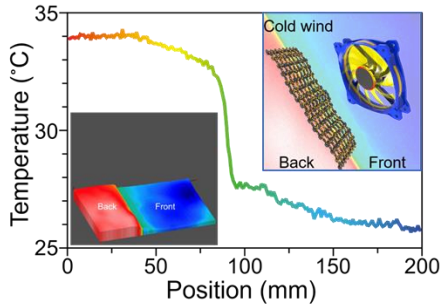


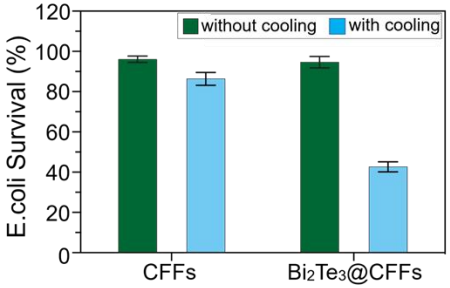


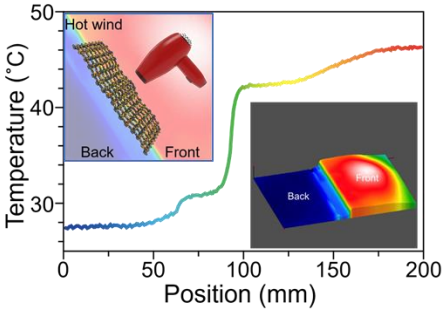


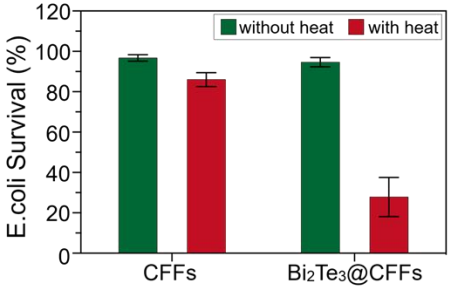
Disinfection performance of thermocatalytic filter with cooling and heating effect



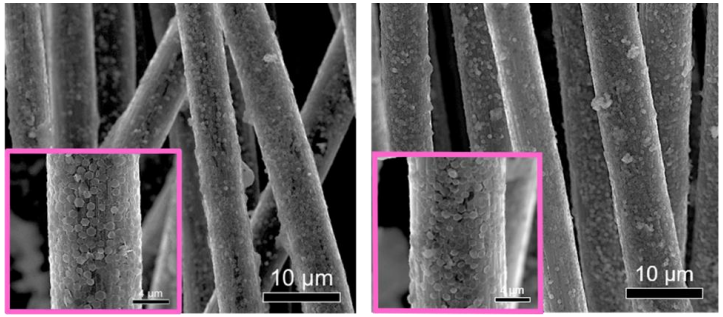


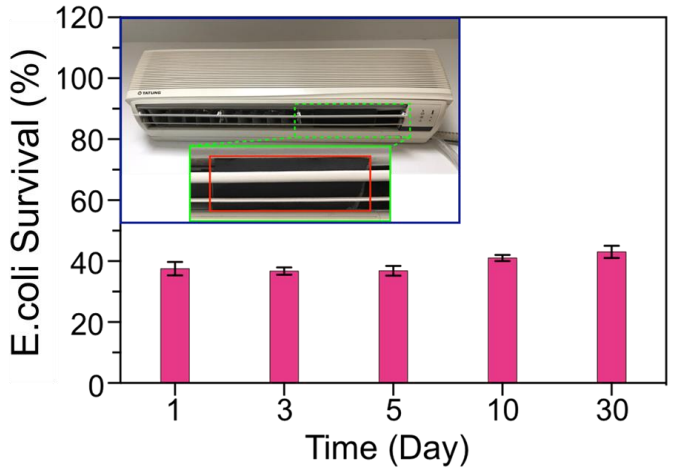


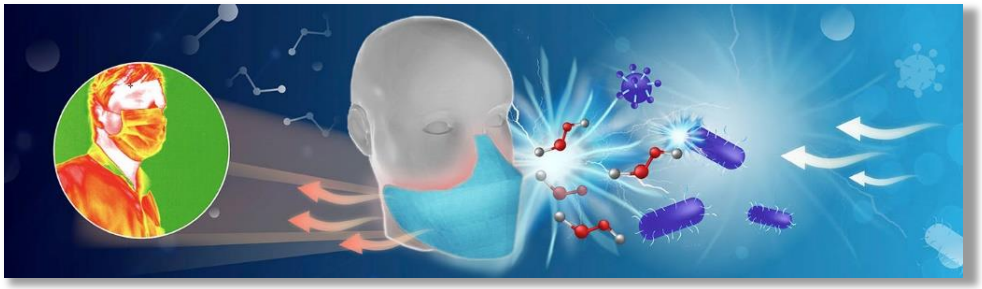




Real-time application of antibacterial filter and its reusability test

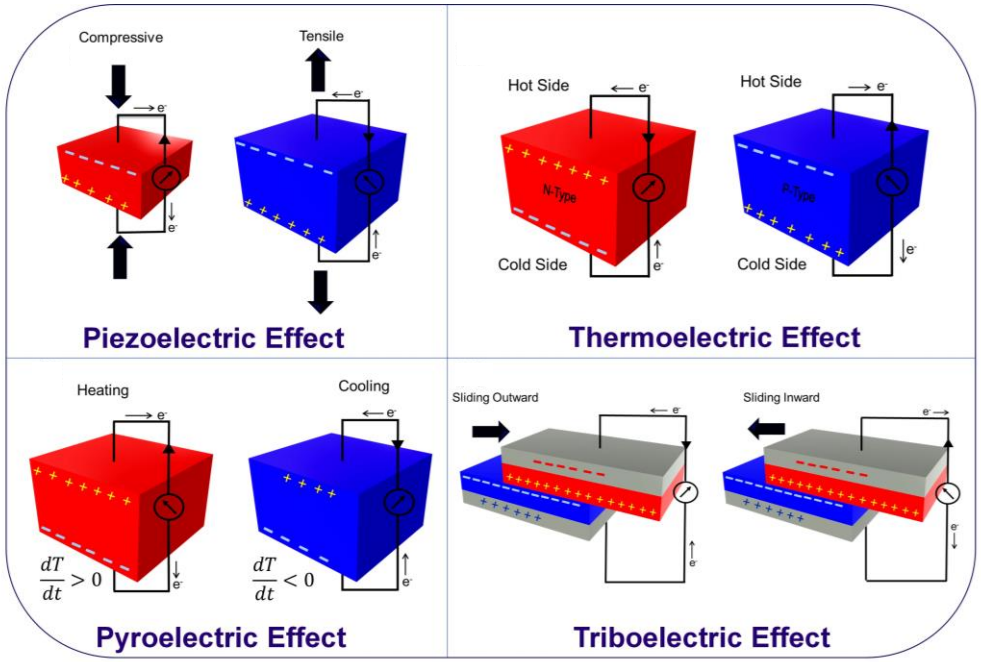


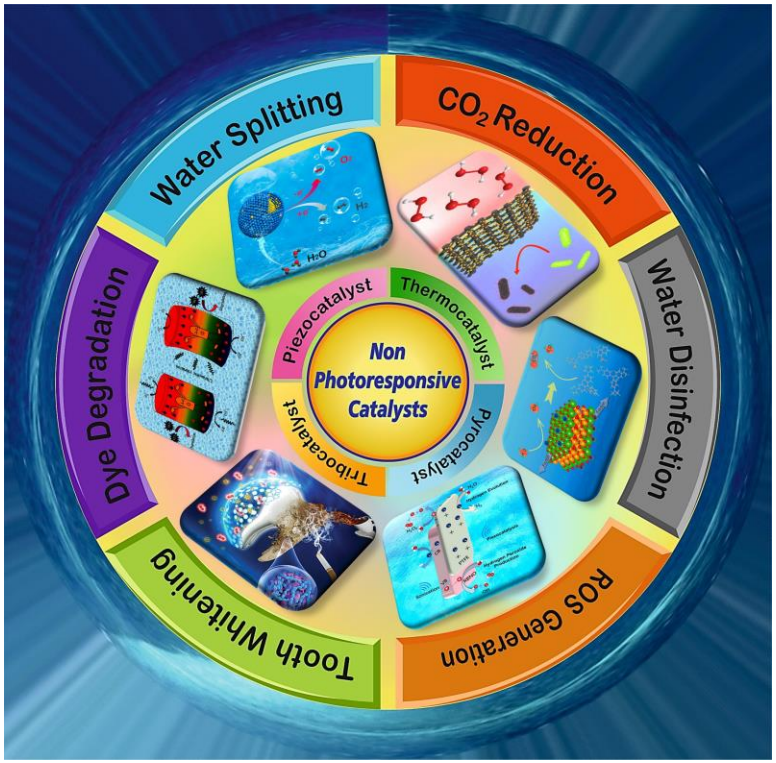




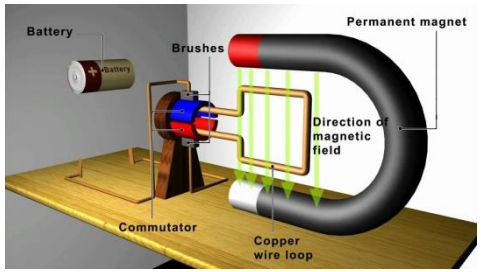
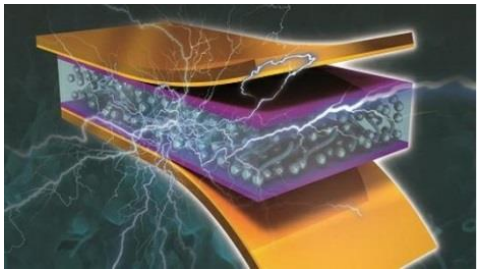
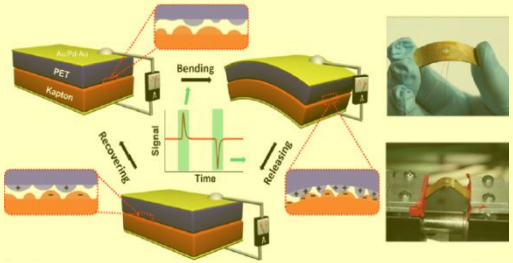
Non-Photoresponsive Catalysts

Chem. Asian J. **2023**, e202300090



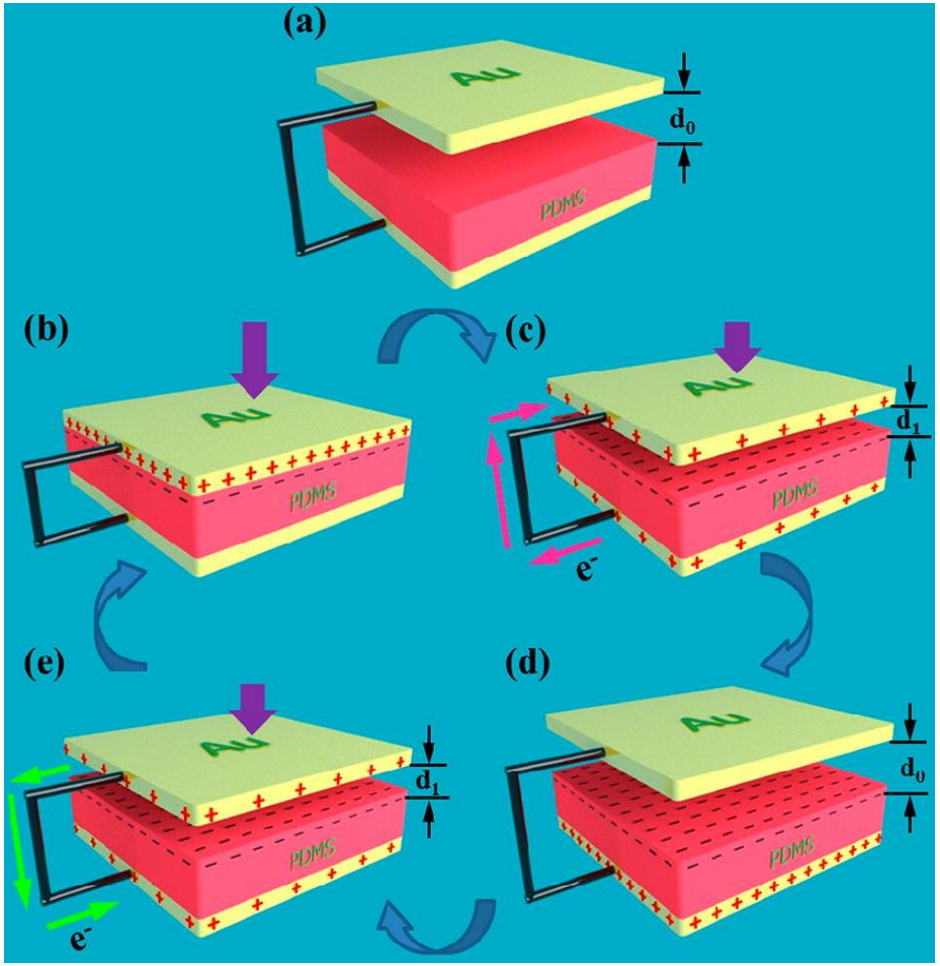


Possible approaches to convert biomechanical energy and provide electrical stimulation

	Electromagnetic generator (EMG)	Piezoelectric nanogenerator (PENG)	Triboelectric nanogenerator (TENG)
Device	Since ~1830 	2007 	2012 
Principle	Faraday's law (electromagnetic induction)	Piezoelectric and electrostatic effects	Triboelectric and electrostatic effects
Materials	Metal, magnet	**Piezoelectric nanomaterials**	**All**
Structure	3D, rigid	**2D, can be flexible**	**2D, can be flexible**

Triboelectric Nanogenerator (TENG)
(Coupling of Triboelectric and Electrostatic Effects)

1. Dielectric constant 2. Work function



→ A new tool for self-powered technology!

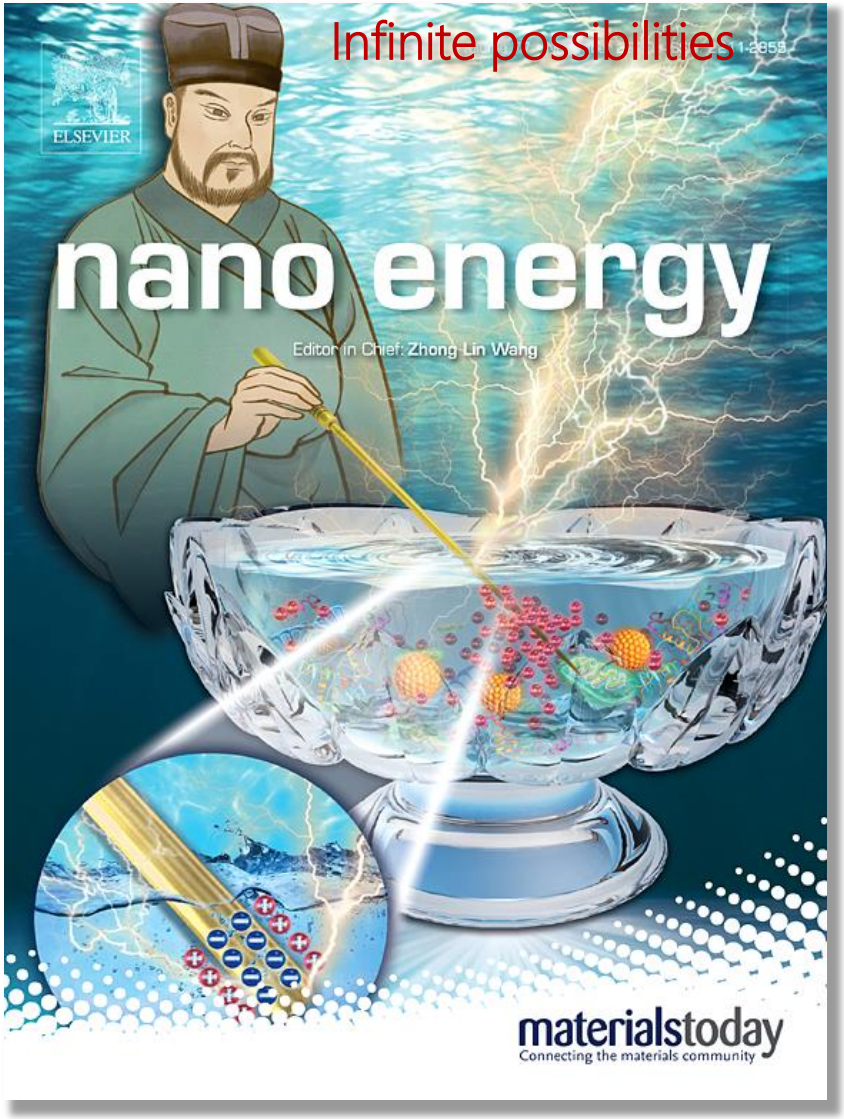
Self-Powered Physical Sensors

- **Open circuit voltage:** it is a measure of the magnitude of the deformation/contact area, which is attributed to the static information to be provided by TENG.
- **Short circuit current:** the output current depends on the rate at which the induced charge would flow, so that the current signal is more sensitive to the dynamic process of how the mechanical triggering is applied.

Self-Powered (Bio)Chemical Sensors

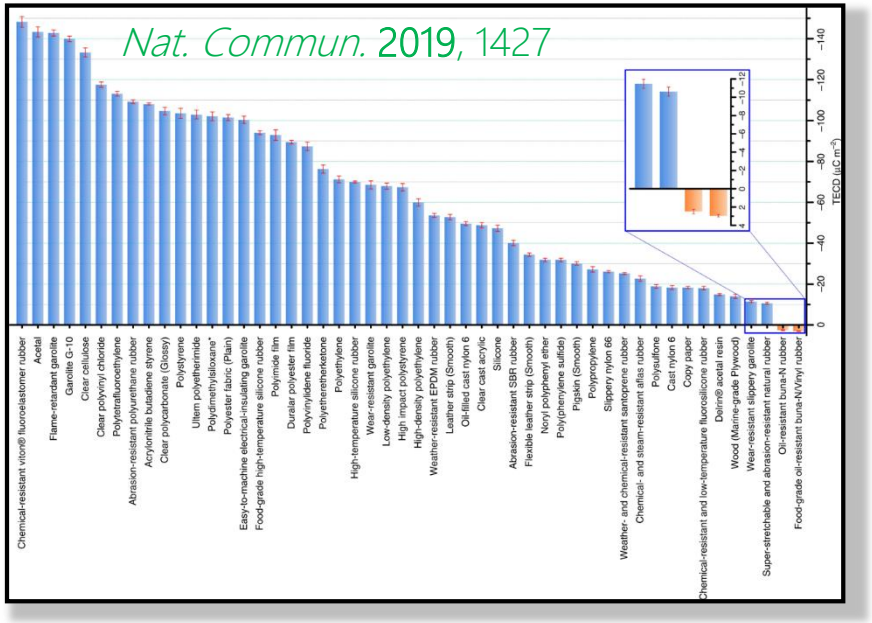
- Because different ions, molecules, and microorganisms have their unique triboelectric polarities, the TENG can become a self-powered sensor when the targets are selectively binding to the contact material surface.

Triboelectric Effect (Contact Electrification)

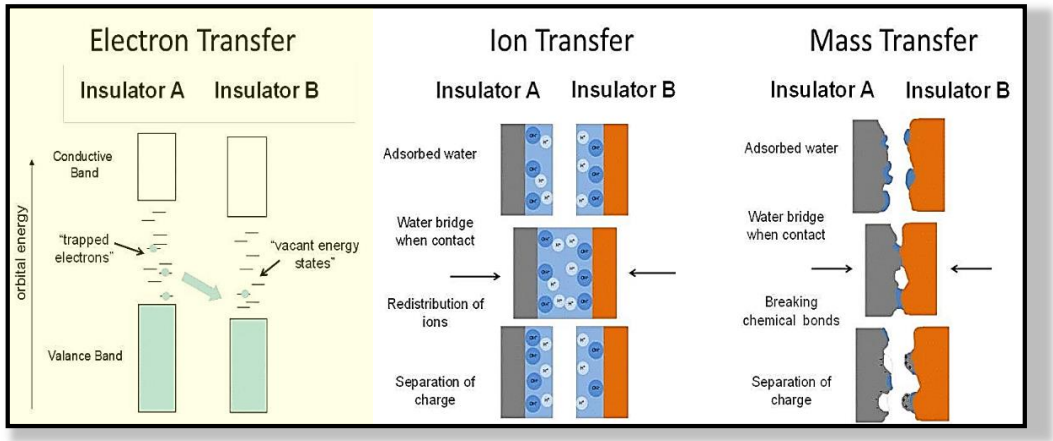


Some points you need to know about the triboelectric effect!

Chemist!



Physicist!



Engineer!

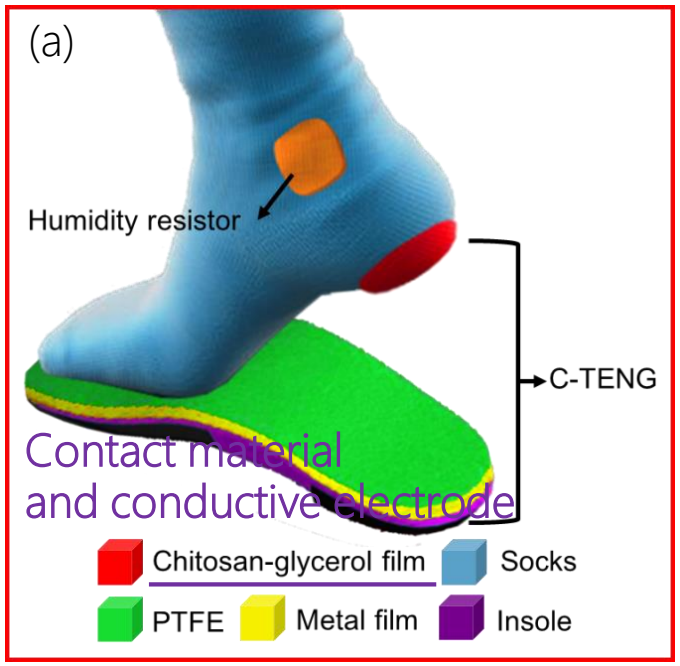
Humidity effect!

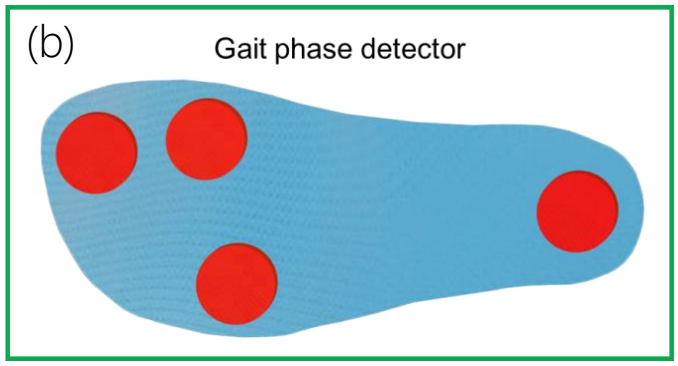
Triboelectric Charging Source	Change in Charge (Volts) at Specified Relative Humidity		
	10%	40%	55%
Walk across carpet	35,000	15,000	7,500
Walk across vinyl tile	12,000	5,000	3,000
Work at seating surface	6,000	500	400
Vinyl envelopes for work instructions	7,000	1,500	750
Common poly bag picked up from worksurface	20,000	6,500	3,000
Work at chair padded with polyurethane foam	18,000	5,000	3,000
Remove circuit boards from standard bubble wrap	26,000	20,000	7,000
Package circuit boards in standard foam-lined box	21,000	11,000	550

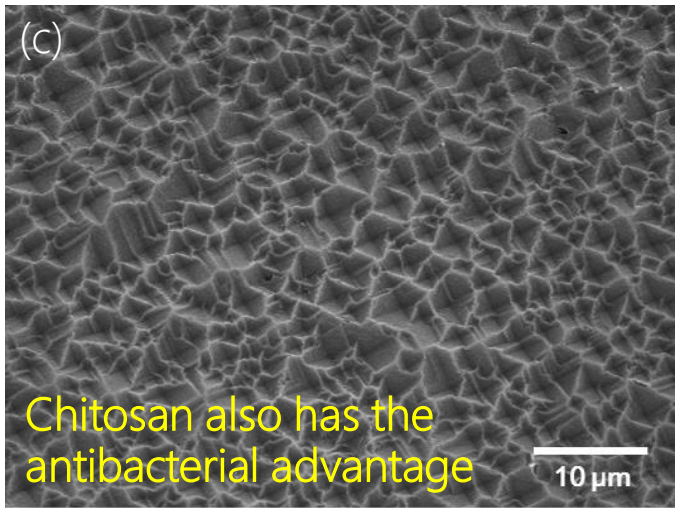
MOST TENG working mechanism!

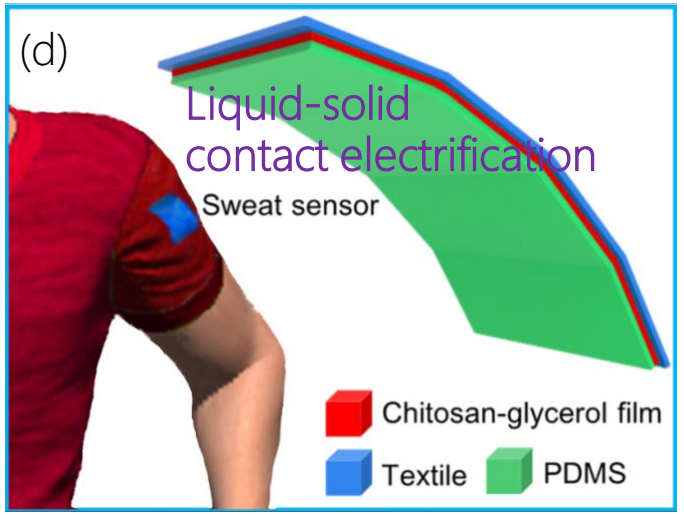
Humidity-Resistant TENG (Solid-Solid Contact Electrification)

Nano Energy 2018, 50, 513-520

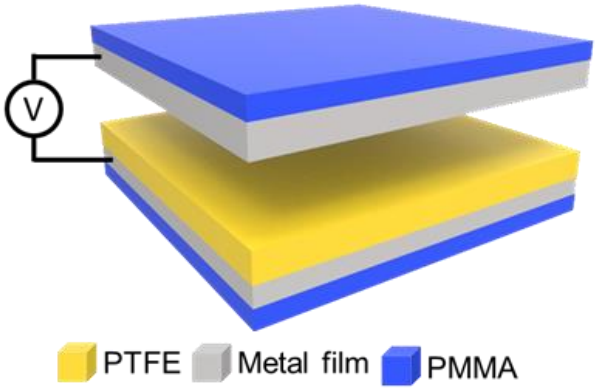


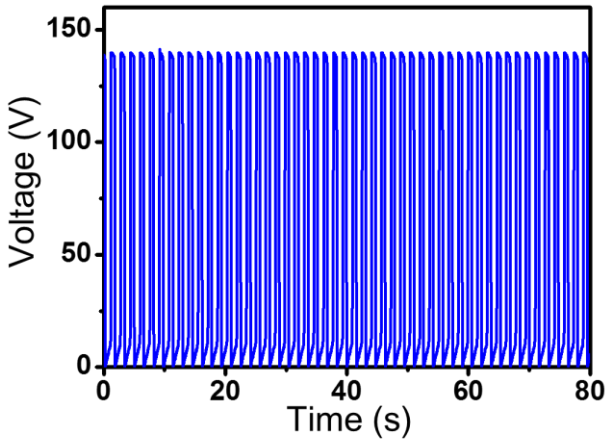


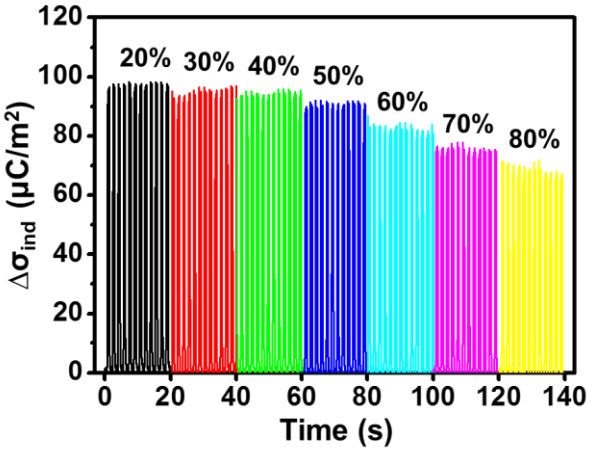




Comparison with Conventional TENG

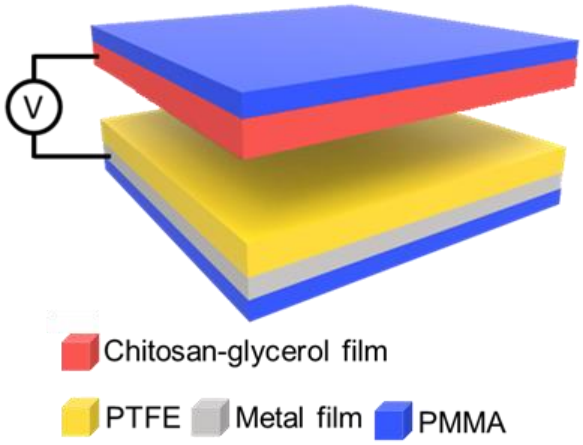


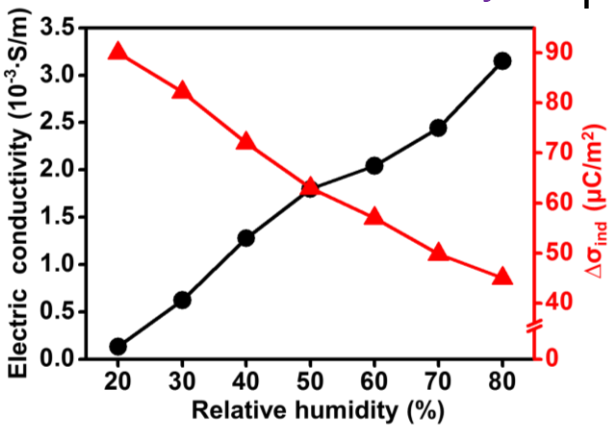


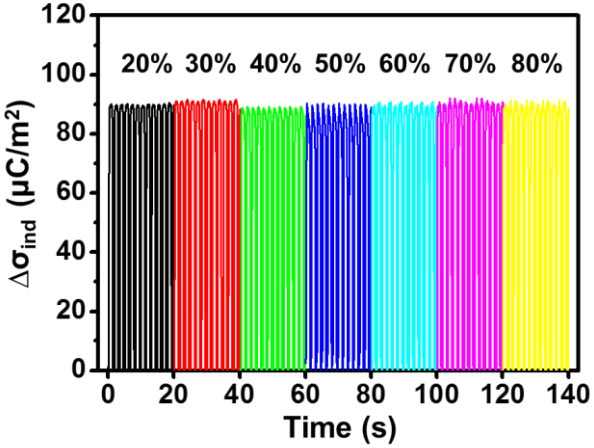


1. Dielectric constant
2. Work function

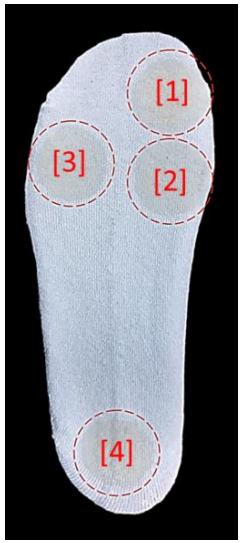
Humidity ↑;
Surface charge density ↓,
however, conductivity ↑

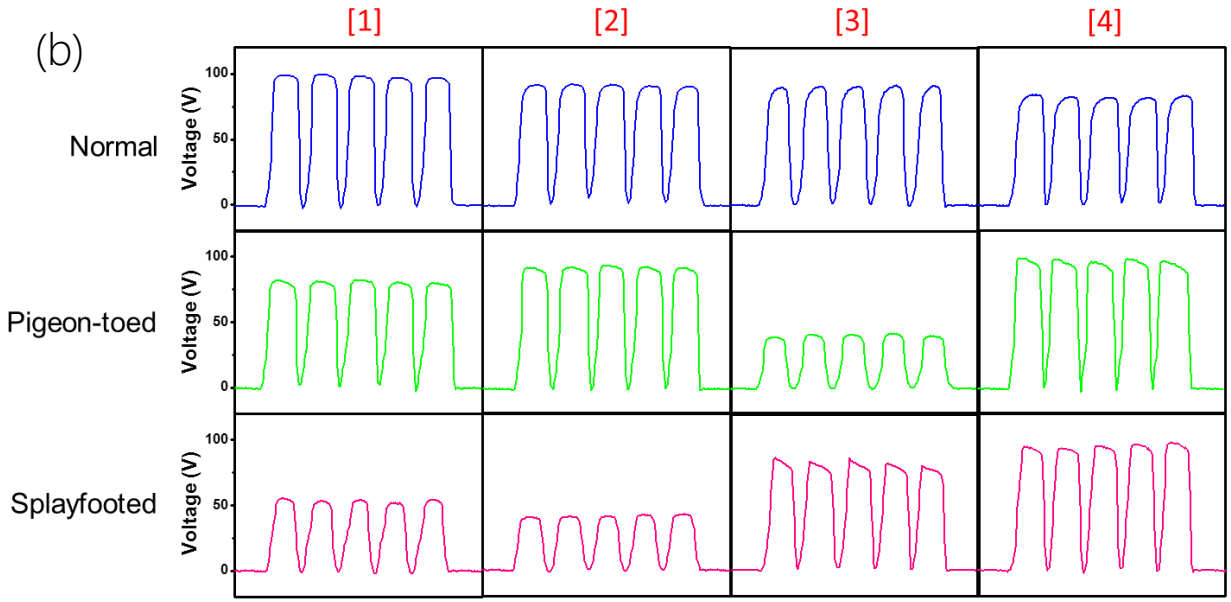


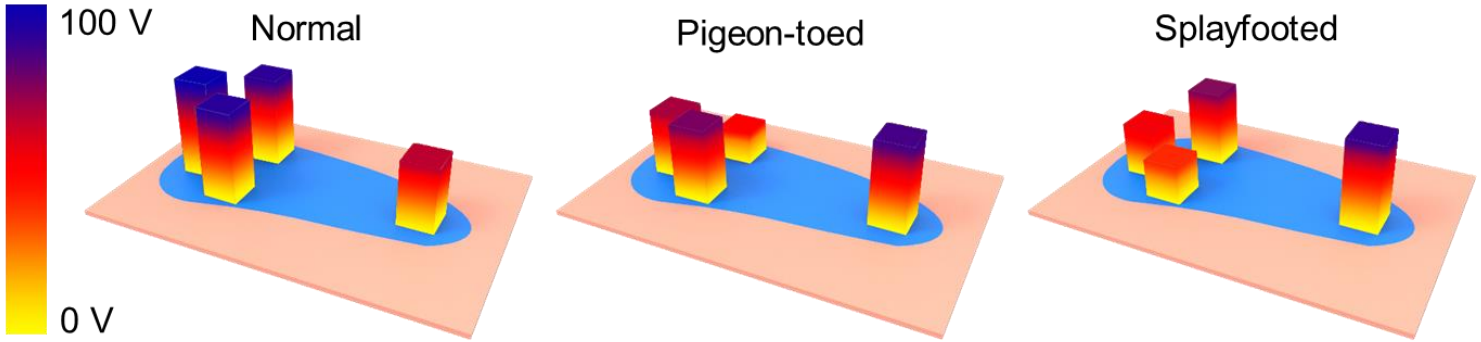




Self-Powered Gait Phase Sensor

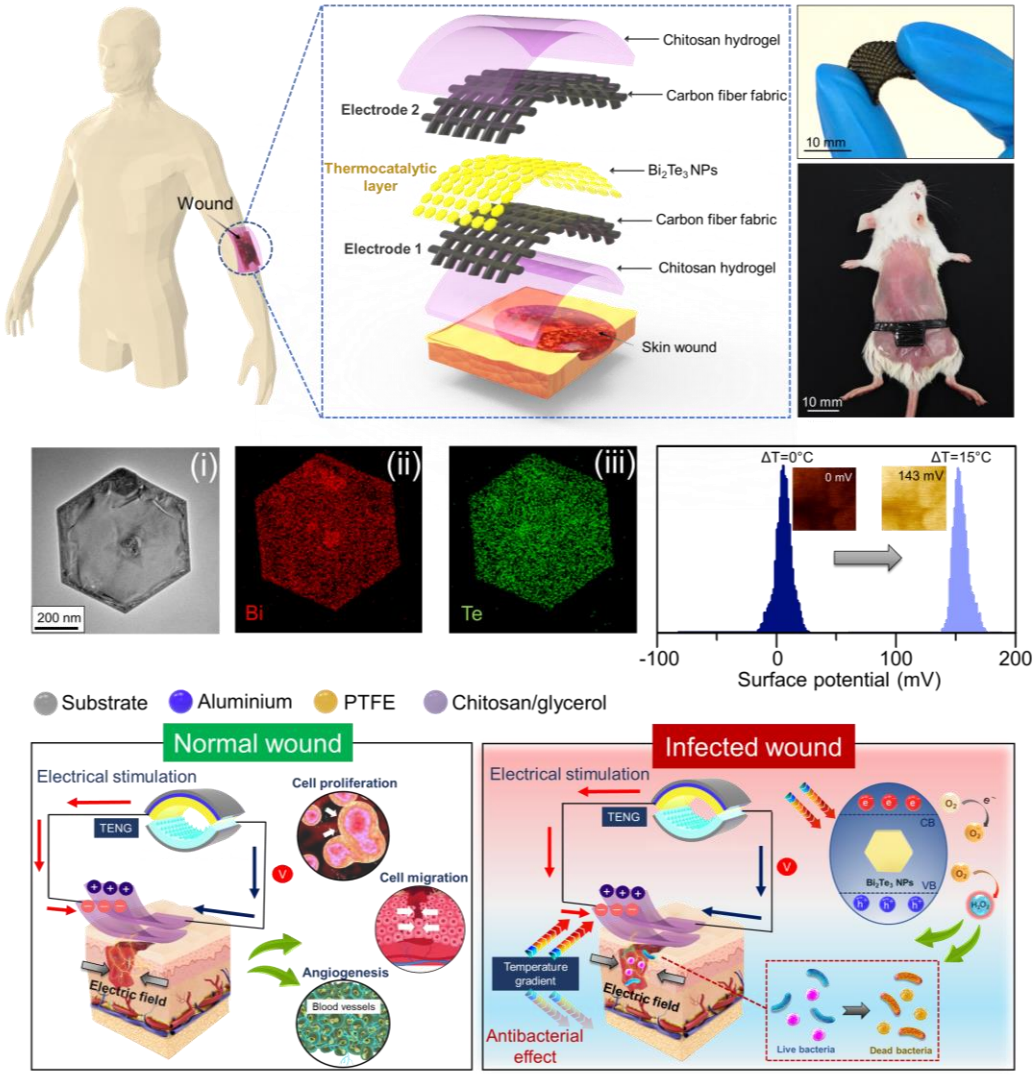






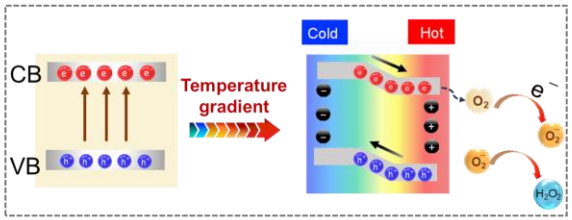
→ Moving forward to scoliosis and bone fracture diagnostic

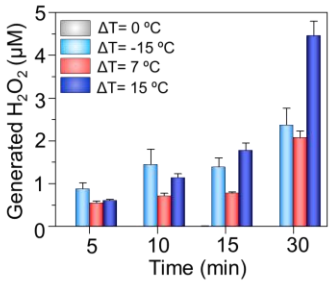
Design of the self-powered wound dressing

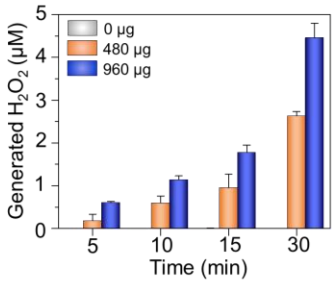


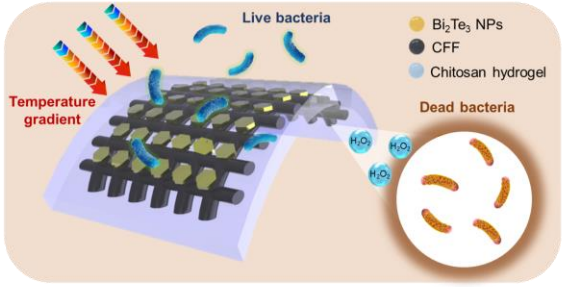
Sci. Adv. **2023**, *9*, eadc8758

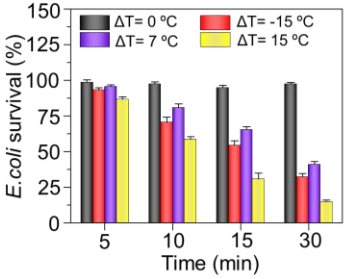
Temperature-dependent antibacterial performance of the smart dressing

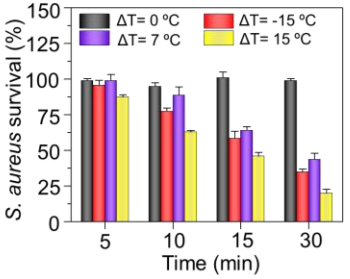


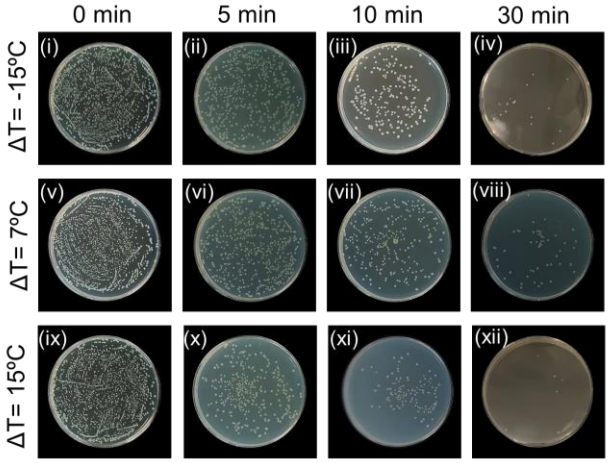


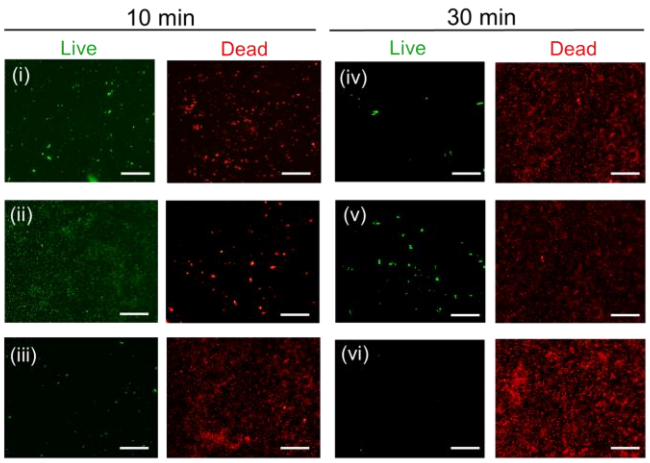




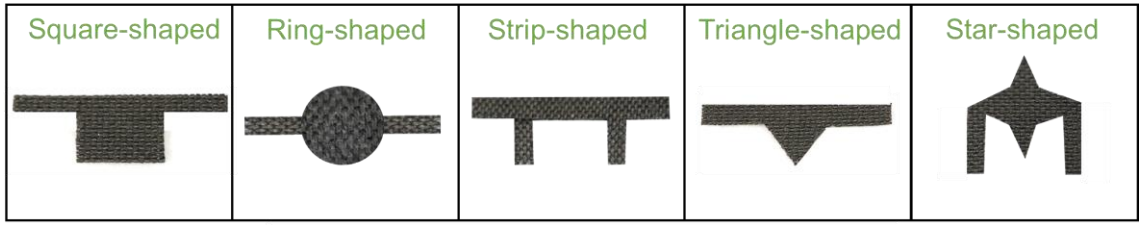


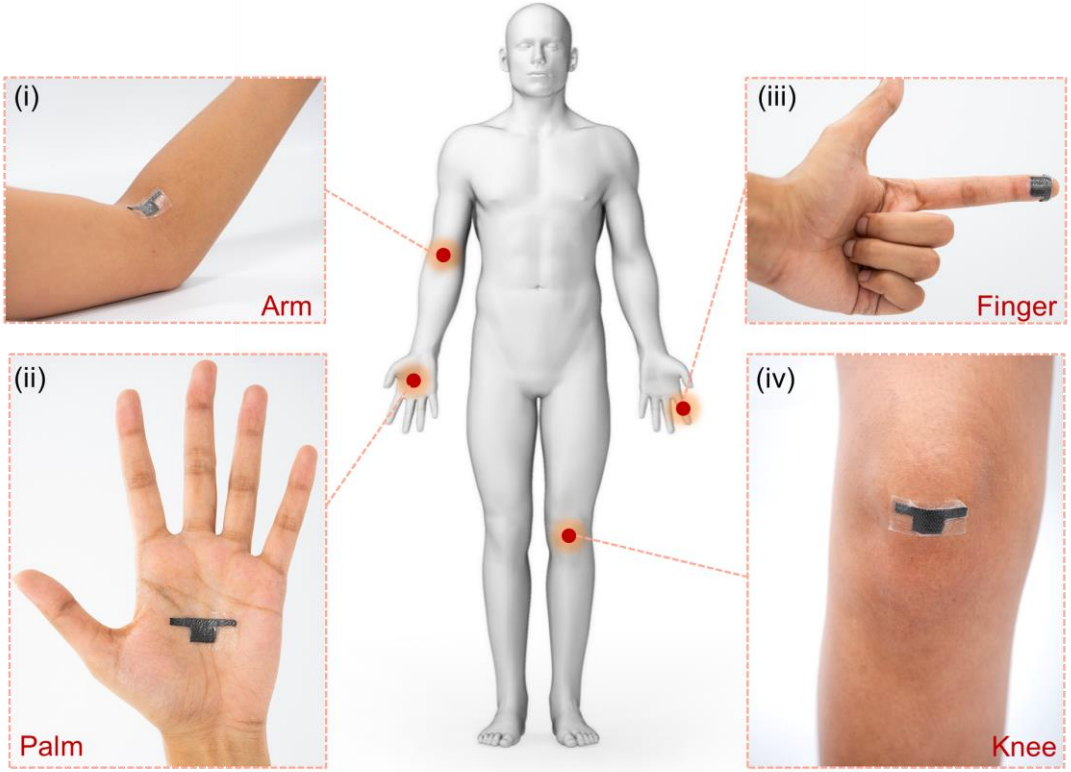




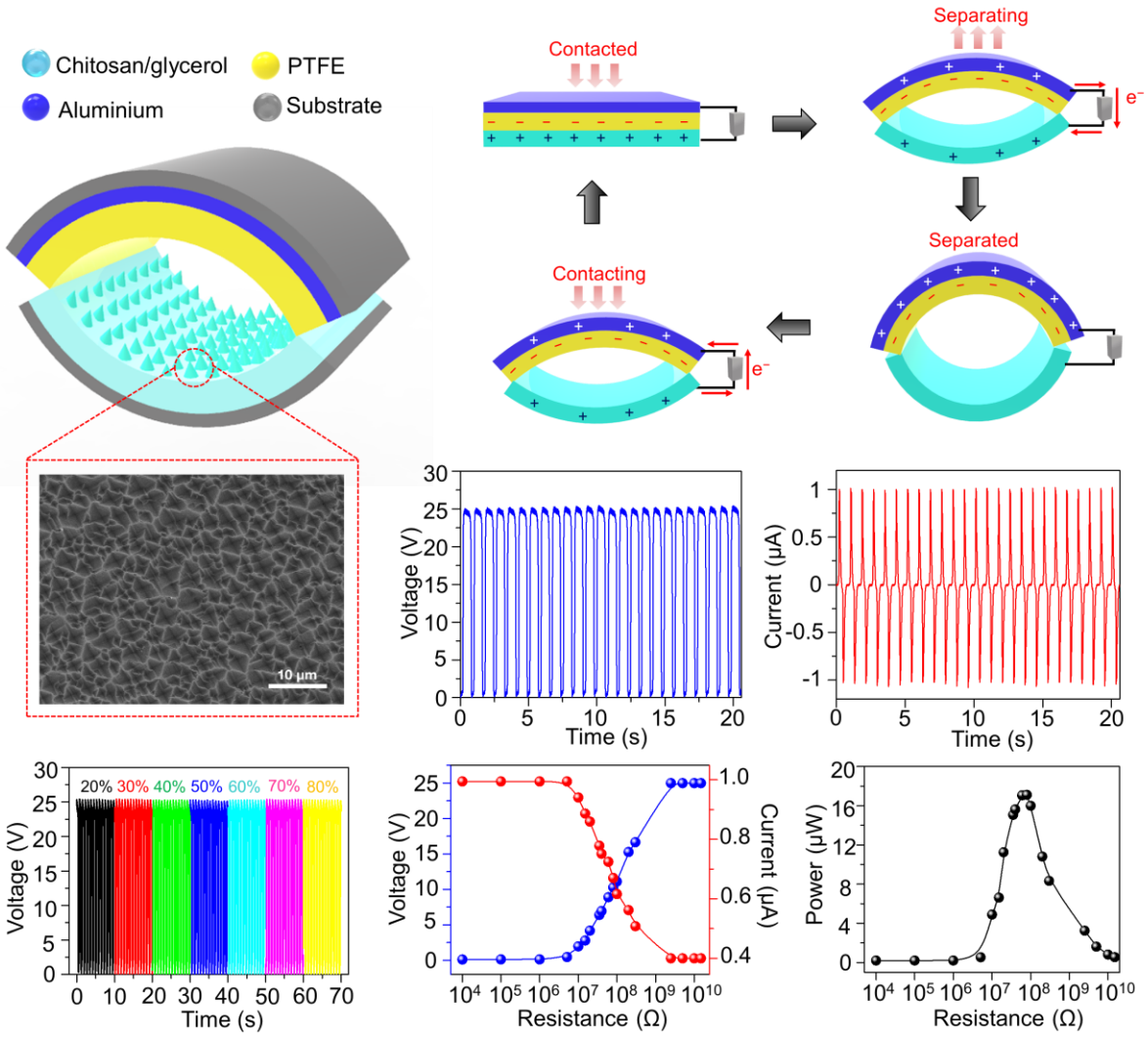


Adaptable nature of the as-designed wound dressing

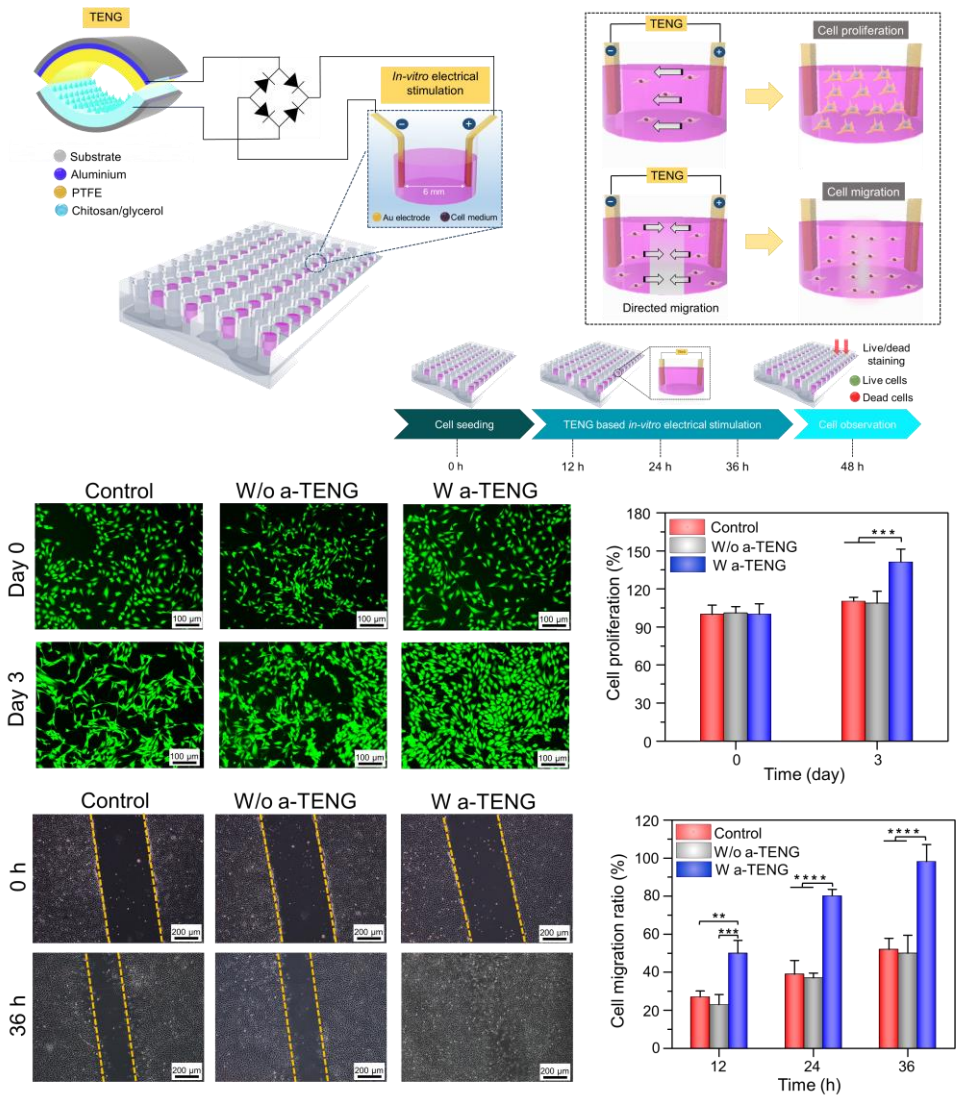




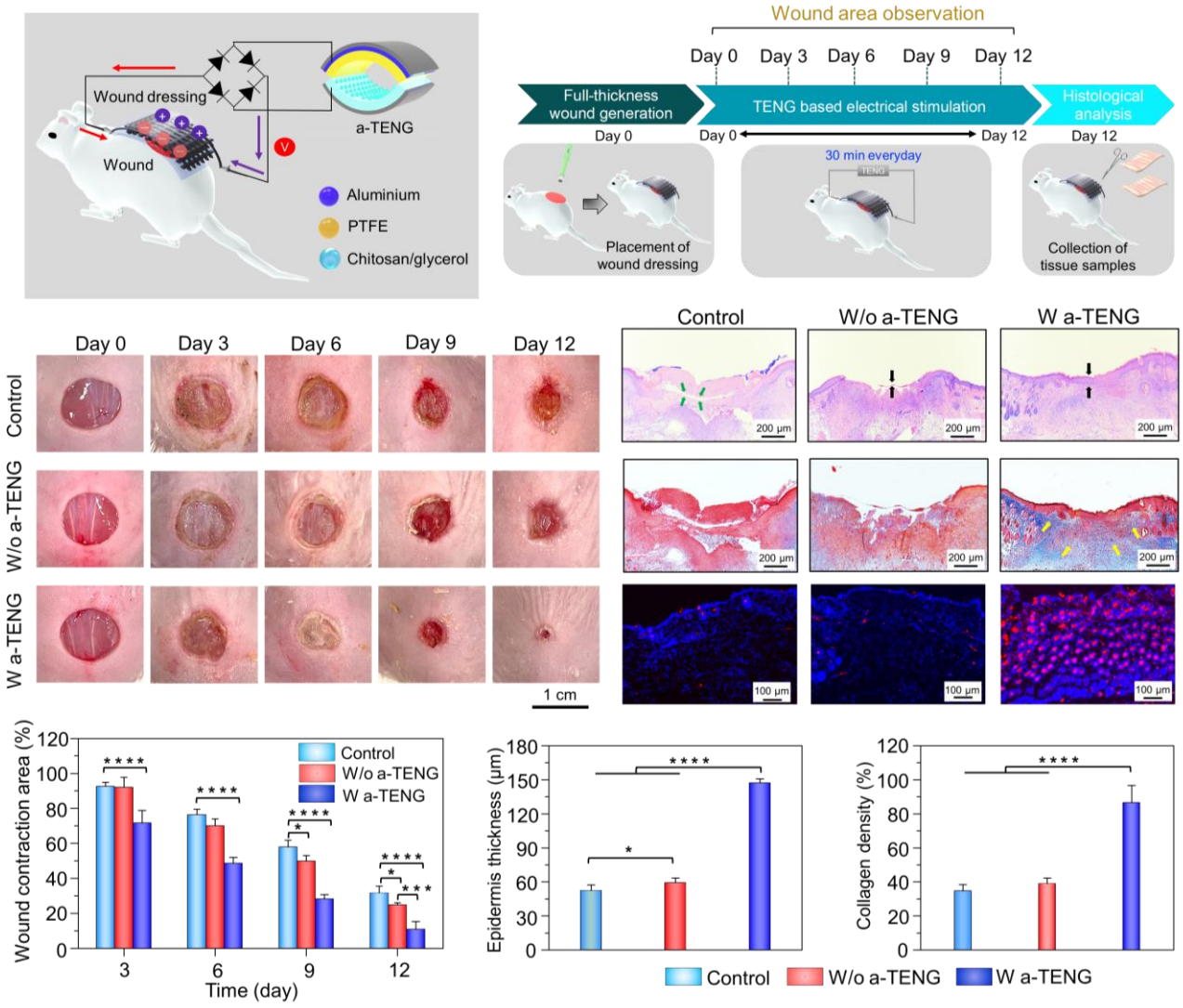
Design and output performance of the TENG



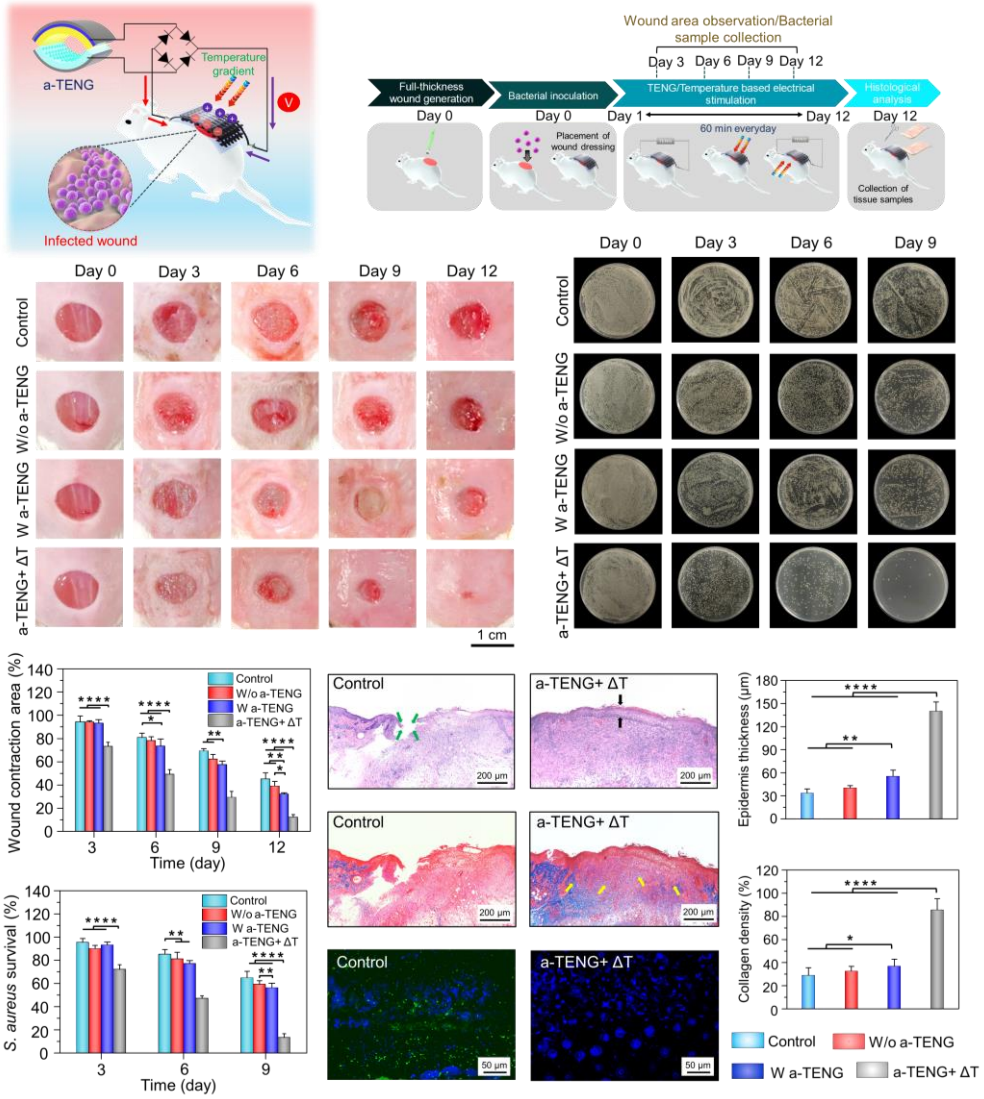
Effect of TENG-induced ES on cellular behavior



TENG-driven treatment strategy for healing normal wounds



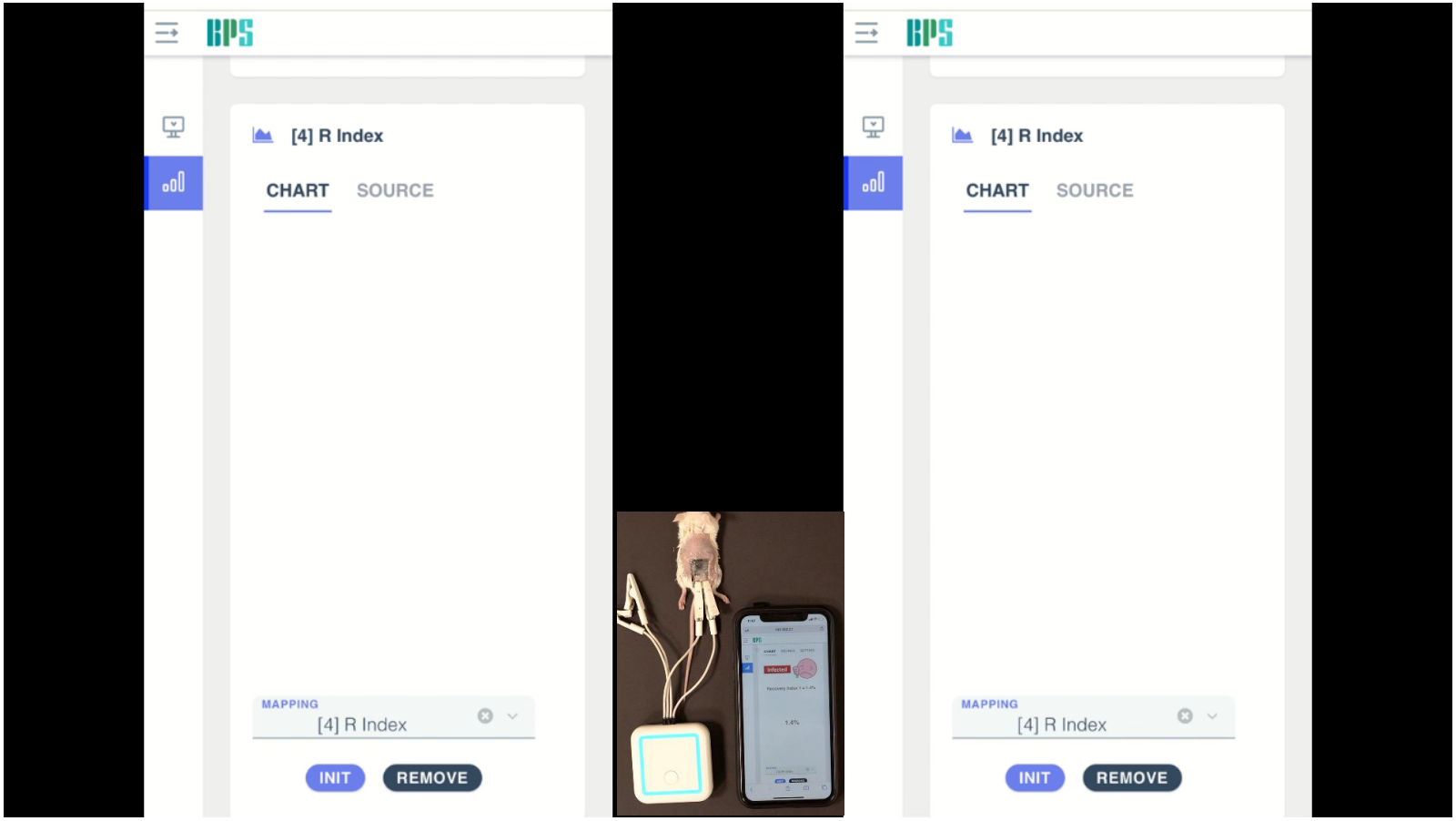
Hybrid treatment strategy for infected wound healing



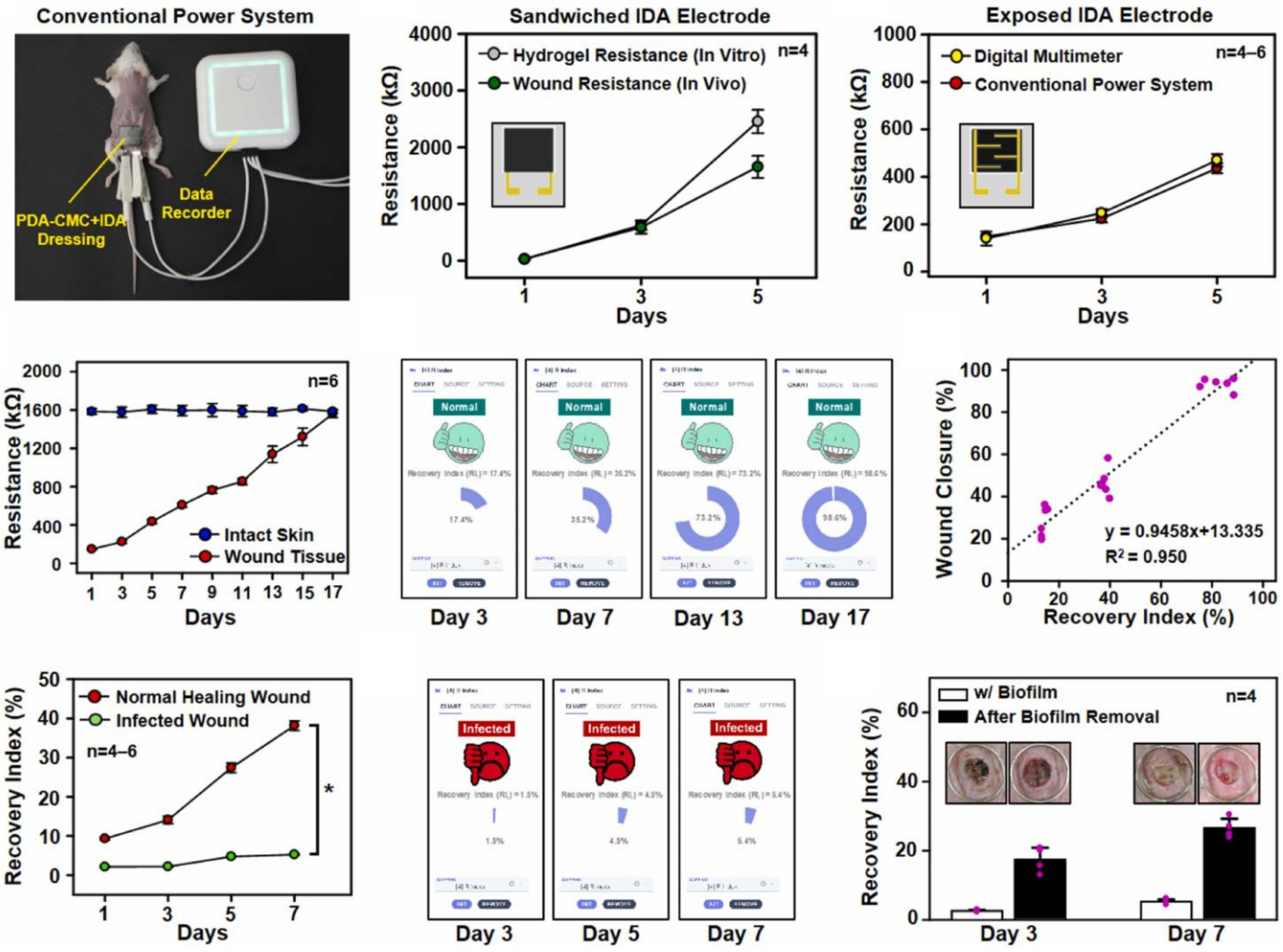
Wireless and continuous monitoring of wound healing by the smart dressing

Prof. Hsing-Wen Sung
(NTHU, Taiwan)

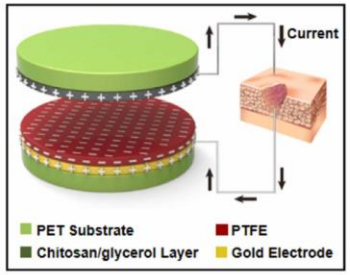
Nano Energy **2022**, *99*, 107393

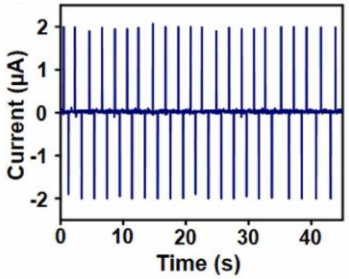


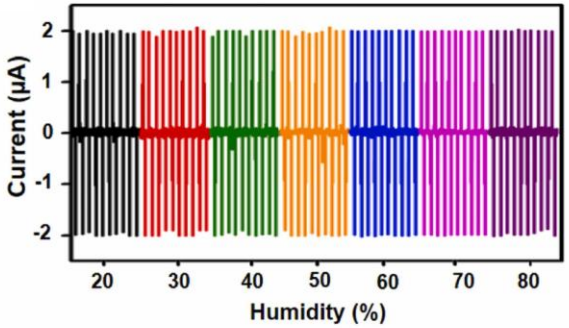
Results of wound monitoring by a conventional power source

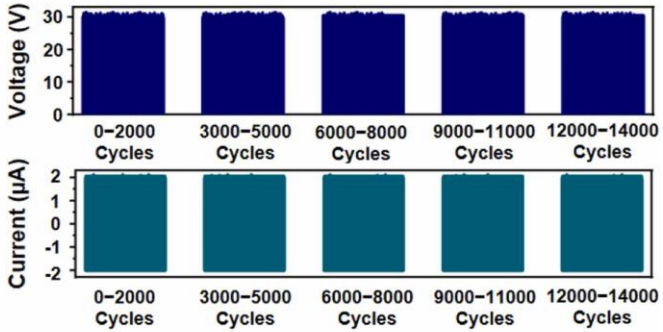


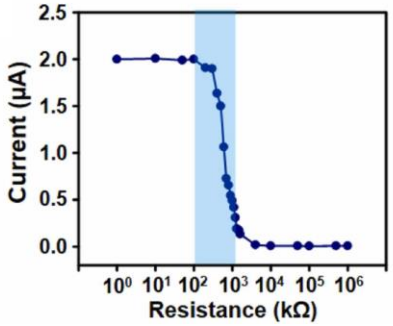
Output characteristics of as-prepared TENG

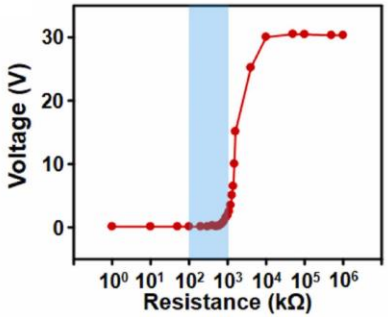


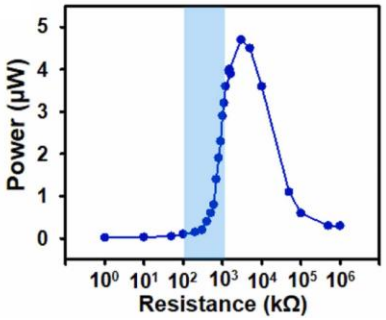




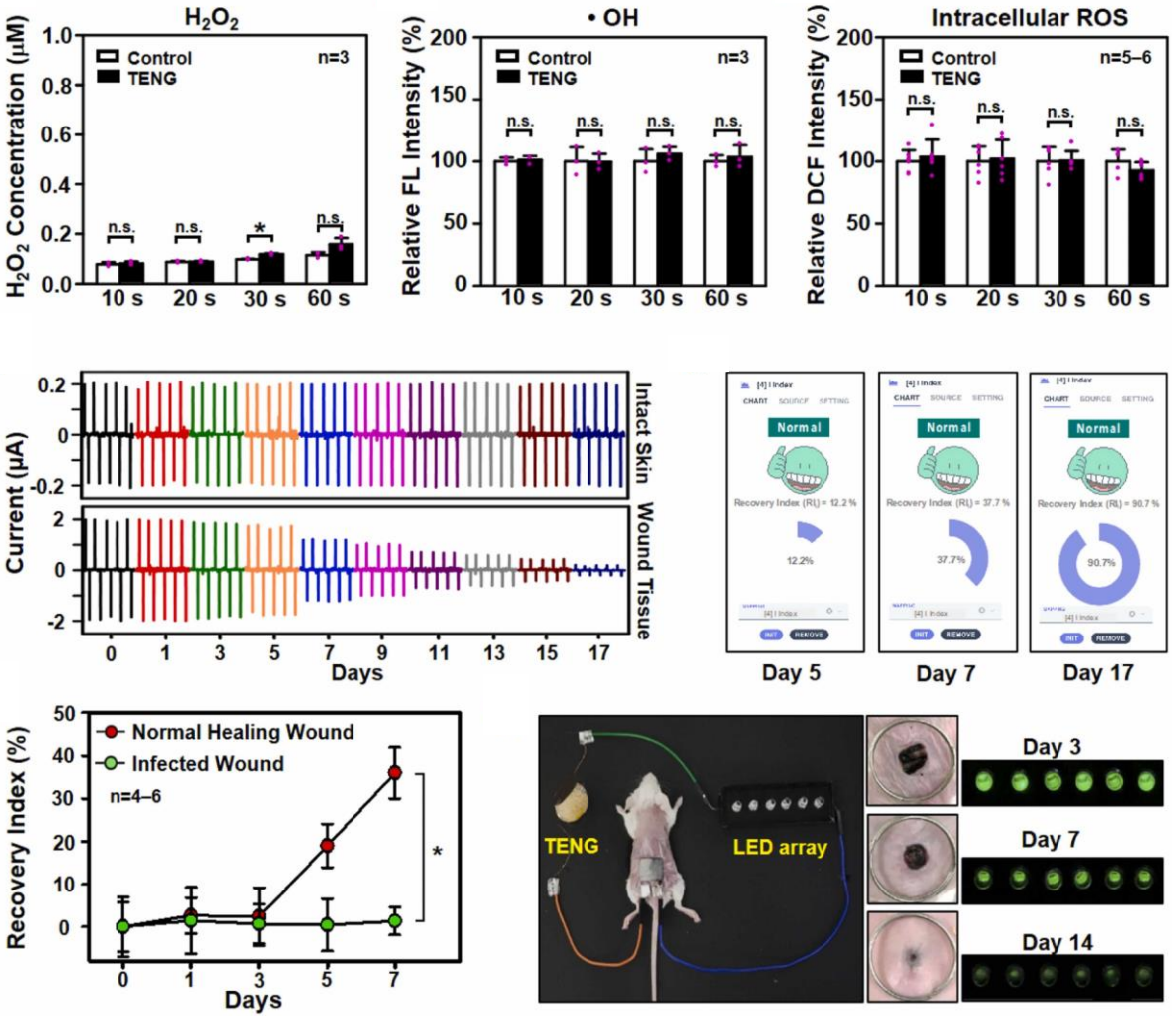








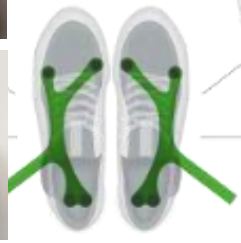
Results of wound monitoring by a self-powered system, TENG



Acknowledgments

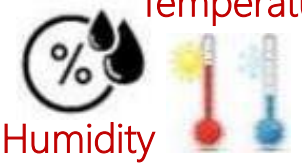
Wearable devices

Pressure



Temperature

Humidity



Smart medicals

Sweat detection

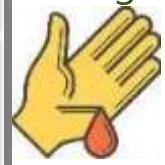
Gesture sensor / robotics

Wound healing sensor

Gait phase detector

Tissue engineering

Wound healing



Neuromodulation

Bone recovery

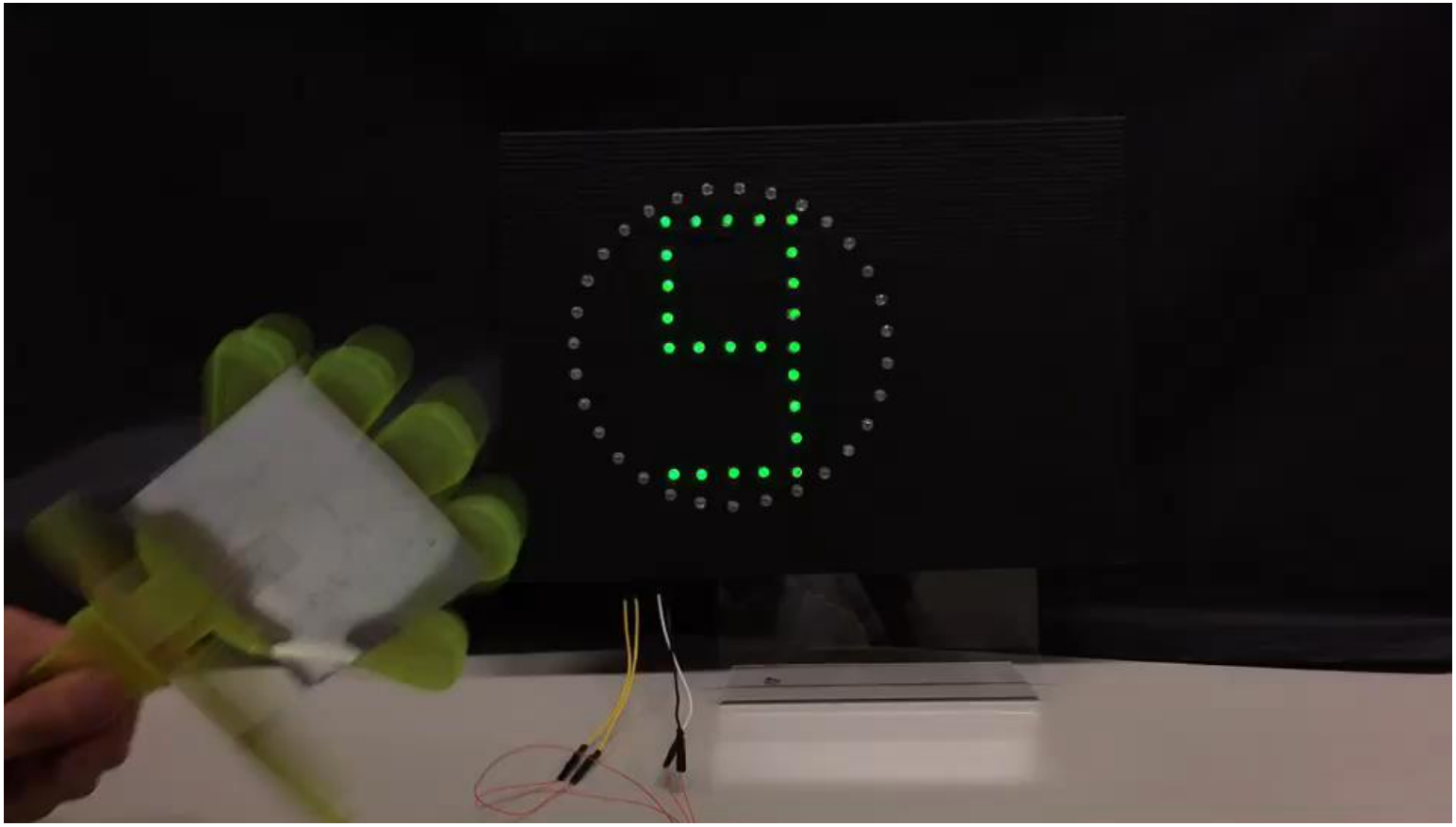
Functional nanomaterials

Wearable/ implantable devices

Bio(chemical) sensors

Triboelectric effect

Thermoelectric effect



Thank you for your attention!

Welcome to any questions, suggestions, comments, and collaboration

http://linzhatnthu.wix.com/suerte