A Self-Powered Smart Glove Based on Triboelectric Sensing for Real-Time Gesture Recognition and Control

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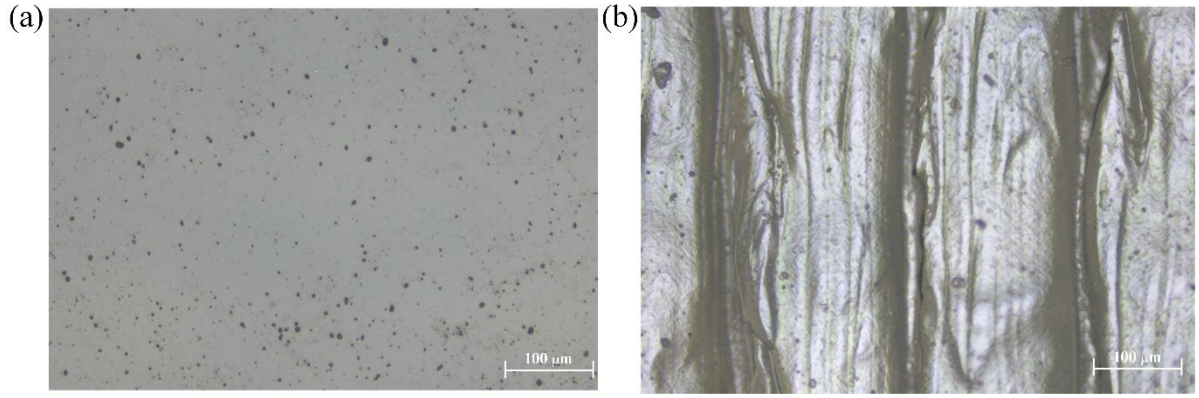


Figure S1. Optical microscopy images of Ecoflex surfaces: (a) smooth surface and (b) rough surface patterned using a 3D-printed mold.

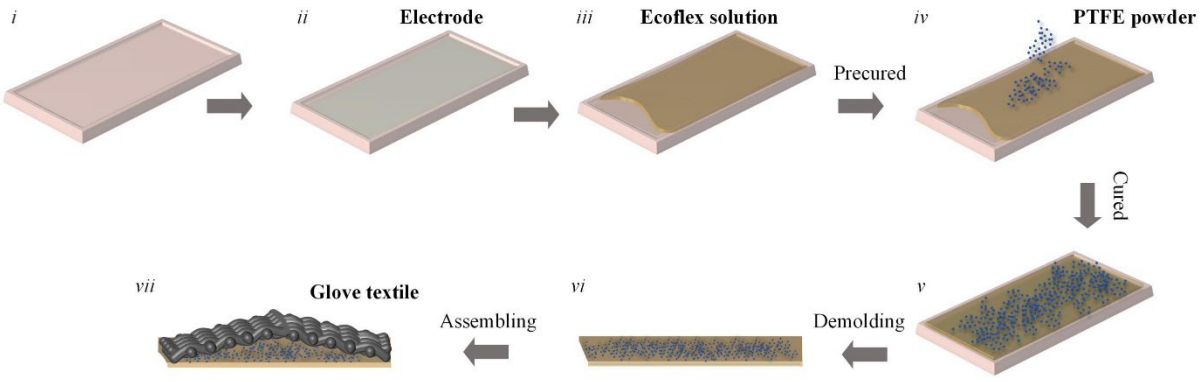


Figure S2. Step-by-step fabrication process of the self-powered TENG sensor, utilizing PTFE-coated Ecoflex as the contact surface.

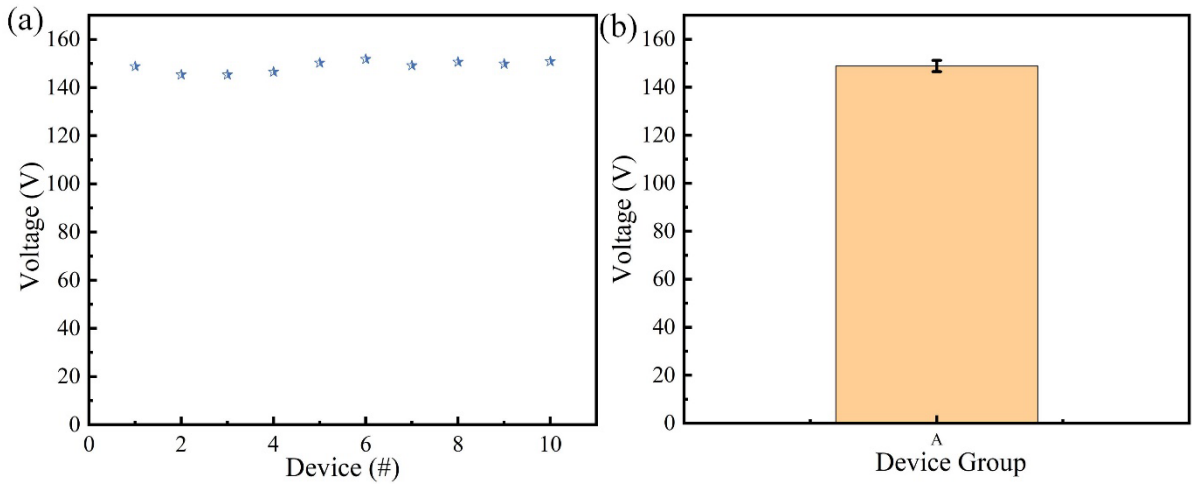


Figure S3. (a) Output voltages of 10 TENG sensors fabricated with the optimized structure, measured under the same force and frequency. (b) Mean output voltage with error bars representing the standard deviation.

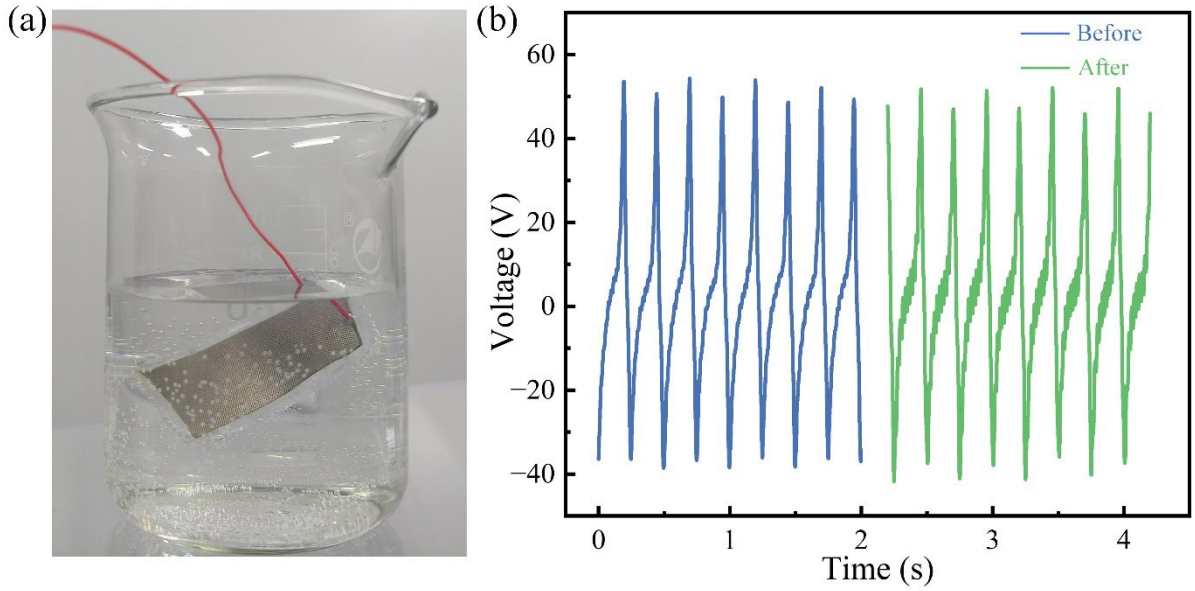


Figure S4. (a) Optical image of the self-powered TENG sensor immersed in water. (b) Voltage output comparison before immersion and after 20 minutes of water immersion followed by drying.

Table S1. Comparison of the proposed TENG sensor and recently reported glove-based TENG HMI systems

Ref.	Materials & Methods	Power Density ($\mu W/cm^2$)	Washa bi-lity	Stretcha bility	Bending Angle Sensitivity	Recogniti on Accuracy	ML Netw ork
[1]	Hydrogel-based TENG with multilayer PVA-SA-PANI + Ecoflex; multi-step synthesis, cross-linking, ultrasonication, spin-coating	3.48×10^{-4}	–	425%	–	99%	FCNN
[2]	Embroidered conductive Ag fiber + FEP film; automatic embroidery and stacking	–	–	-	–	–	–
[3]	CNT-TPE textile + textured Ecoflex (Lotus leaf mimic); ultrasonication, spray-coating, ethanol etching	18	–	-	–	99.4% (gesture), 95.23% (object)	1D-CNN
[4]	PDMS + Ecoflex + Cu mesh; multi-layered configuration	1.25×10^{-5}	–	–	0.04 V/°	93.1% (user)	SVM
[5]	PEDOT:PSS-dipped cotton textile + Ecoflex; dip-coating and manual layering	–	–	–	–	–	–
This Wo rk	Textured Ecoflex (via 3D-printed mold) + conductive fabric; minimalist one-step casting; no post-processing	75.02	√	Limited*	–**	99.2% (user), 97.0% (object)	1D-CNN

Notes: * Limited by the textile electrode but designed for natural finger bending via arc-shaped configuration. ** Angle-resolved sensitivity not tested due to manual control limitations; most state-of-the-art systems also omit this. High output usually suggests high sensitivity.

SI references:

[1] Wang, C.; Niu, H.; Shen, G.; Li, Y. Self-Healing Hydrogel-Based Triboelectric Nanogenerator in Smart Glove System for Integrated Drone Safety Protection and Motion Control. *Adv. Funct. Mater.* **2024**, 2419809, doi:10.1002/adfm.202419809.

[2] Xu, G.; Wang, H.; Zhao, G.; Fu, J.; Yao, K.; Jia, S.; Shi, R.; Huang, X.; Wu, P.; Li, J.; et al. Self-Powered Electrotactile Textile Haptic Glove for Enhanced Human-Machine Interface. *Sci. Adv*. **2025**, *11*, eadt0318, doi:10.1126/sciadv.adt0318.

[3] Wen, F.; Sun, Z.; He, T.; Shi, Q.; Zhu, M.; Zhang, Z.; Li, L.; Zhang, T.; Lee, C. Machine Learning Glove Using Self-Powered Conductive Superhydrophobic Triboelectric Textile for Gesture Recognition in VR/AR Applications. *Adv. Sci*. **2020**, *7*, 2000261, doi:10.1002/advs.202000261.

[4] Luo, Y.; Wang, Z.; Wang, J.; Xiao, X.; Li, Q.; Ding, W.; Fu, H.Y. Triboelectric Bending Sensor Based Smart Glove towards Intuitive Multi-Dimensional Human-Machine Interfaces. *Nano Energy* **2021**, *89*, 106330, doi:10.1016/j.nanoen.2021.106330.

[5] He, T.; Sun, Z.; Shi, Q.; et al. Self-powered glove-based intuitive interface for diversified control applications in real/cyber space. *Nano Energy* **2019**, *58*, 641-651, doi: https://doi.org/10.1016/j.nanoen.2019.01.091