

Supplementary

A Hybrid Triboelectric-Electromagnetic Nanogenerator Based on Arm Swing Energy Harvesting

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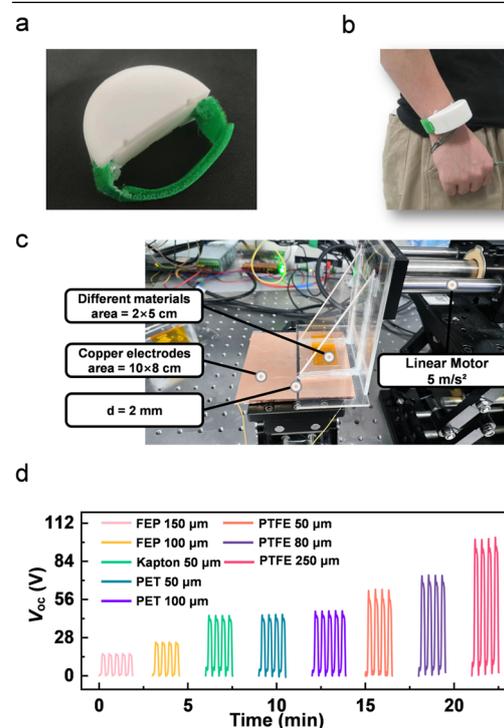


Figure S1. (a) The actual drawing of HNG. (b) The physical picture of HNG is worn on the hand. (c) Schematic diagram of the platform setup for testing performance output of different materials. (d) The output voltage of the TENG with different triboelectric materials.

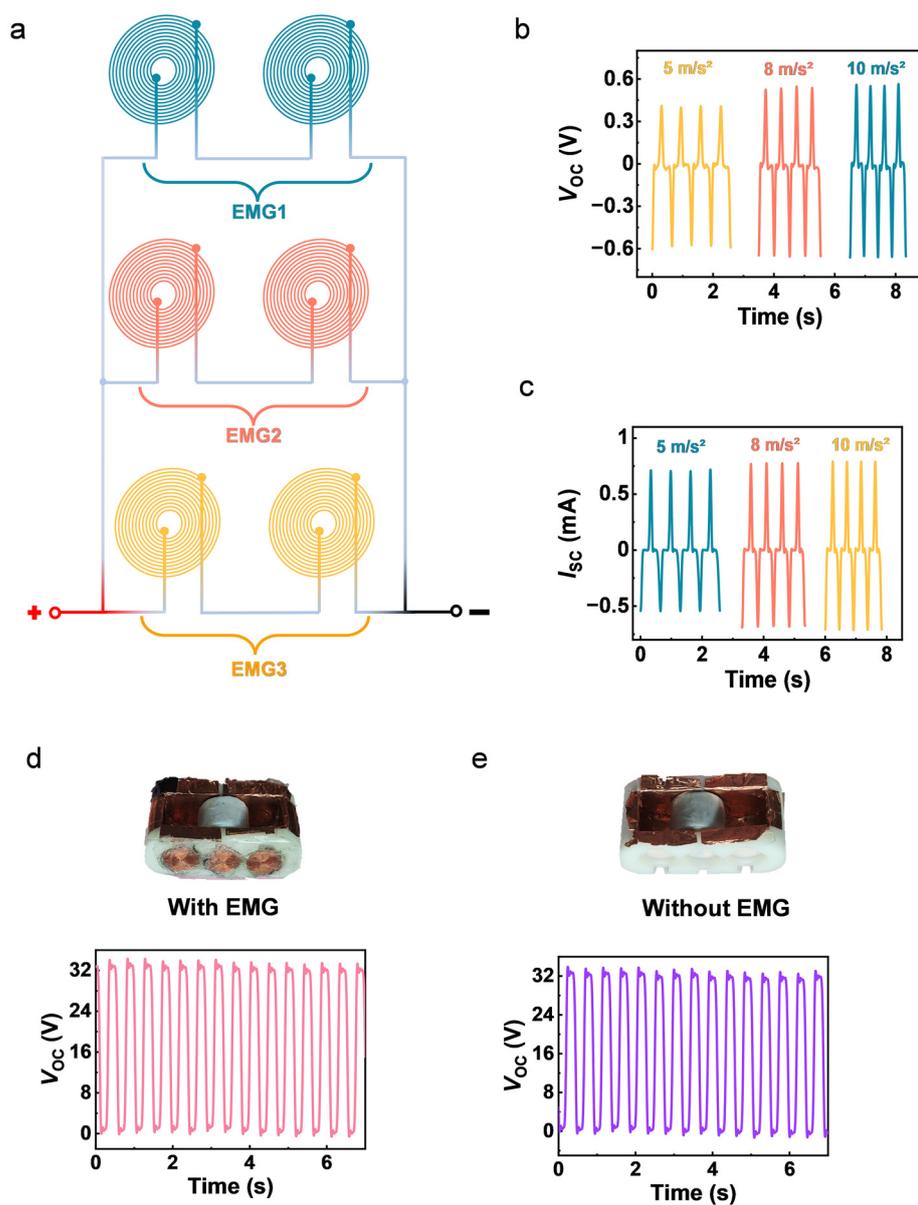


Figure S2. (a) Connection in parallel of EMGs. (b) The V_{oc} of EMGs in parallel at accelerations of 5 m/s^2 , 8 m/s^2 , 10 m/s^2 . (c) The I_{sc} of EMGs in parallel at accelerations of 5 m/s^2 , 8 m/s^2 , 10 m/s^2 . (d) The voltage output of TENG with EMG. (e) The voltage output of TENG without EMG.

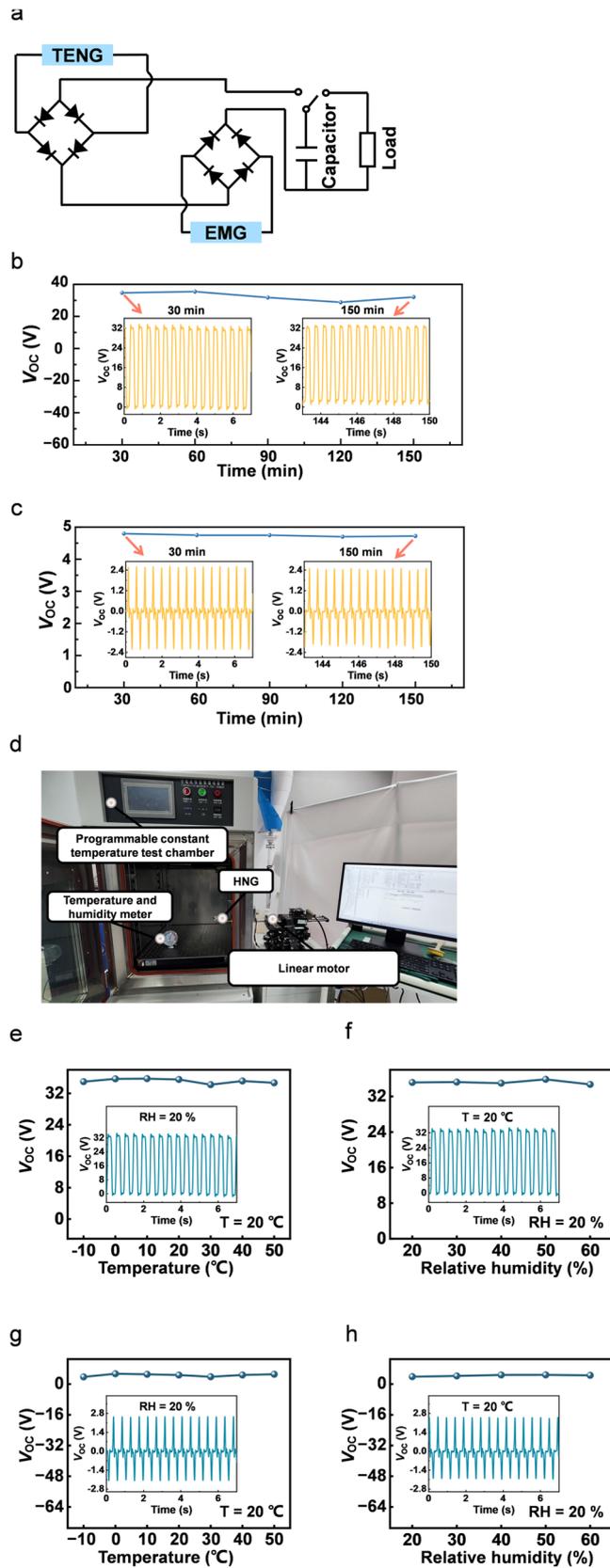


Figure S3. (a) Schematic diagram of the rectifier circuit of TENG and EMGs in series connection. (b) Stability and durability testing of TENG. (c) Stability and durability testing of EMG. (d) Display of temperature and humidity testing platform. The open-circuit voltage of the TENG is influenced by (e) relative humidity and (f) temperature. The open-circuit voltage of the EMG is influenced by (g) relative humidity and (h) temperature.

Table S1. The main performance parameters and advantages of the proposed nanogenerator with respect to other hybrid nanogenerators.

Title	Occupied Volume (mm ³)	Voltage Ratio per Unit Volume of the TENG (V/mm ³)	Current Ratio per Unit Volume of the EMG (mA/mm ³)	Maximum Frequency (Hz)	Energy Sources
Self-powered sensing for smart agriculture by electromagnetic-triboelectric hybrid generator [35]	≈18,522,000	≈0.702 × 10 ⁻⁶	≈0.626 × 10 ⁻⁶	62.1	Wind energy
Rotating-disk-based hybridized electromagnetic-triboelectric nanogenerator for scavenging biomechanical energy as a mobile power source [36]	≈183,000	≈0.4098 × 10 ⁻³	≈0.315 × 10 ⁻³	600	Biomechanical energy
Hybrid energy cell for harvesting mechanical energy from one motion using two approaches [37]	≈405,000	≈0.148 × 10 ⁻²	≈0.2469 × 10 ⁻⁵	22	Mechanical energy
This work	≈35,342	≈0.105 × 10 ⁻²	≈0.143 × 10 ⁻⁴	2.17	Biomechanical energy

Table S2. Coil parameters

Parameter	Value
Coil-wire diameter	0.04 mm
Length of each coil	29,000 mm
Each coil turns	6100 circles

Note S1**The FEM model using COMSOL.**

In a triboelectric nanogenerator (TENG), the initial boundary conditions used to generate the figures in the article for the two-dimensional electrostatic physics simulation performed using COMSOL were as follows: a surface charge density of $q_1 = -9 \times 10^{-12}$ was applied to the edge of a circular magnet with radius R , and a surface charge density of q_2 was applied to the two copper electrodes with side lengths of $L + \pi \times R$. The total charge on the circular edge was set to be equal to the sum of the charges on the two copper edges, with $q_2 = -q_1 \times R \times \pi / (L + R \times \pi) = 4.174 \times 10^{-12}$. In addition to the model being plotted, a large rectangle was also plotted to represent the air domain, with all four sides grounded and set as the reference potential zero point.

Note S2

Convert the parameter settings of the linear motor into frequency using formulas (1), (2), (3).

$$t_a = \frac{v_{max}}{a} \quad (1)$$

$$d_a = \frac{1}{2} a t_a^2 \quad (2)$$

$$f = \frac{v_{max}}{2d_a} \quad (3)$$

We can calculate that the corresponding frequencies for 5 m/s², 8 m/s² and 10 m/s² are 1.04 Hz, 1.67 Hz and 2.17 Hz, respectively.