**Supporting Information for**

# Biodegradable, Super-Strong and Conductive Cellulose Macrofibers for Fabric-Based Triboelectric Nanogenerator

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## Supplementary Figures and Tables

### Supplementary Figures

**Supplementary Tables**



**Supplementary Movies**

Table S1. Summary and comparison of fabric-based TENGs based various

| Mode | Electrodes | Triboelectric materials | Structures | Power outputs | Stretchability/durability | Washability | Applications | Ref. |
|---|---|---|---|---|---|---|---|---|
| SE | Cu fiber | Silicone and polyester | Nanofiber | 25 V, 12.8 nA (40 Hz) | 20000 cycles | 60 min | Sleep monitoring | 13 |
| CS | Ni coating | Cotton and parylene | 2D weaving | 40 V, 5 μA, 2.42 mW $cm^{-1}$ (5 Hz) | 10000 cycles | - | Energy harvesting | 14 |
| FT | Ag fabric | Skin and mxene/silicon | 2D weaving | 1.34 kV, 55 W $m^{-2}$ | 86000 cycles | - | Energy harvesting | 15 |
| CS | Al foil | Nylon fabric and PVDF | Fabric stacking | 2 V, 200 nA | Durable | 50 times | Pulse signal monitoring | 16 |
| SE | Stainless-steel rod | Silicone rubber and polyester | 2D weaving | 10.79 Mv/Pa | 20000 cycles | Washable | Sleep monitoring | 17 |
| SE | Au foil | Water drop, waterproof fabric | Fabric stacking | 15 V, 4 μA, 0.14 W $m^{-2}$, (100 MΩ) | Stretchable and durable | Waterproof | Water energy | 18 |
| CS | Ag yarn | PA66 and PTFE | Fabric stacking | 50 V, 0.9 μA, 7.531 W m-2 (40 MΩ) | 45%, 6000cycles | - | Energy harvesting | 19 |
| SE | CNT coating | Skin fabric and skin | Fabric stacking | 7 V, 180 nA (2 Hz) | 2000 bending | Washable | Touch sensor | 20 |
| CS | Graphene coating | PTFE and nylon | 3D spacer | 3 V, 0.3 μA, 16 μW (0.6 MΩ) | - | - | Pressure sensing | 21 |
| FT | Carbon fabric | PI/PU and AI/PDMS | Lateral sliding | 15 V, 140 nA (3 cm $s^{-1}$) | Durable | - | Energy harvesting | 22 |
| CS | CNTcoating | Cotton thread and PTFE | 2D weaving | 12.5 V, 11.22 nA, 11.08 Nw (100 MΩ) | 2.15% | - | Motion sensor | 23 |
| CS | PPy coating | PDMS and cotton | Fabric stacking | 200 V, 6 μA, 82 μW $cm^{-2}$ | 5000 cycles | - | Energy harvesting | 24 |
| CS | PEDOT:PSS | PEDOT:PSS and silicone rubber | Multiarch | 0.2 V(160% strain) | 160%/4 h | Washable | Wearable keyboard | 25 |
| SE | PEDOT:PSS coating | PEDOT:PSS and PFTE | Fabric stacking | 49.7 V, 787 nA, 2.67 Mw (9 MΩ) | 160% | Washable | multi-arch strain sensor | 26 |
| SE | KI-Gly | Silicone rubber and Acylic | Lateral sliding | 300 V, 17.5 Mw m-2 | 250% |  | Motion sensing | 27 |
| SE | Galinstan liquid electrode | Silicone rubber skin | 2D wearing | 130 V ,4 μA (2Hz) | 300% | - | Wearable electronics | 28 |
| SE | Ag NWs/CNT | Ag NWs/CNT/PDMS | Coaxial structure | 22 V, 7.5 nC, 21.516 μW (150 MΩ) | 1800 times | - | Tactile sensor and motion sensor | 29 |

SE:single electrode; CS: contact-separation; FT: freestanding triboelectric-

Table S2. Degradable or green materials for fabricating TENG

| Triboelectric Materials | Preparing method | Electrodes | Output performance | Durability | Degradation time | Applications | Ref. |
|---|---|---|---|---|---|---|---|
| PLGA film | Electrospining | Ag nanowires | 97 V, 1.5 μA, 130 mW $m^{-2}$ | 50000 times | - | E-skin, monitoring of physiological signal | 33 |
| Starch flim | Casting | Al film | 2.1V | 4600 cycles | 15 days | Energy harvesting | 34 |
| Diatom-CNF film | Vacuum filtration | Al tapes | 380 V, 18 μA, 80 mW $m^{-2}$ (5 Hz) | - | - | Energy harvesting, breath sensing | 35 |
| Laver film | Vacuum filtration | Ag leaf | 23 V, 315 nA 0.8 mW $m^{-2}$ | 1000 cycles | 28 days | Energy harvesting | 36 |
| Chitosan based film | Casting | Al film | 13.5 V, 42 nA, 17.5 μW $m^{-2}$ (5 Hz) | 8400 times | 15 min | - | 37 |
| Rice paper | Sticking | Conductive ink | 392 V, 16.7 μA 82.69μW $m^{-2}$ (5 Hz) | 10000 cycles | - | Energy harvesting | 38 |
| Silk nanofiber membrane | Electrospining | Al film | 18 V 4.3 mW $m^{-2}$ (5 Hz) | 25000 cycles | - | Energy harvesting | 39 |
| BC film | Bacterial synthesis | BC composite | 29 V, 0.6 μA, 0.08 μW (5 Hz) | 10000 cycles | 7 hours | Energy harvesting Self-powered interface | 40 |
| Plant protein film | Casting | PEDOT:PSS gel | 20.3 V, 1.26 μA | 40000 cycles | 127 days | mulch film for crop growth | 41 |
| PLA and gelatin | Electrospining and casting | Mg electrode | 500 V, 5 W $m^2$ | 13500 cycles | 20 days | Energy harvesting | 42 |
| BC macrofiber | Wet-stretching and twisting | BC composite macrofiber, Al membrane | 170 V, 7.5μA, 54.14 mW m-2 (5 Hz) | 1000 cycles | 108 hours | Energy harvesting, motion monitoring | Ours |

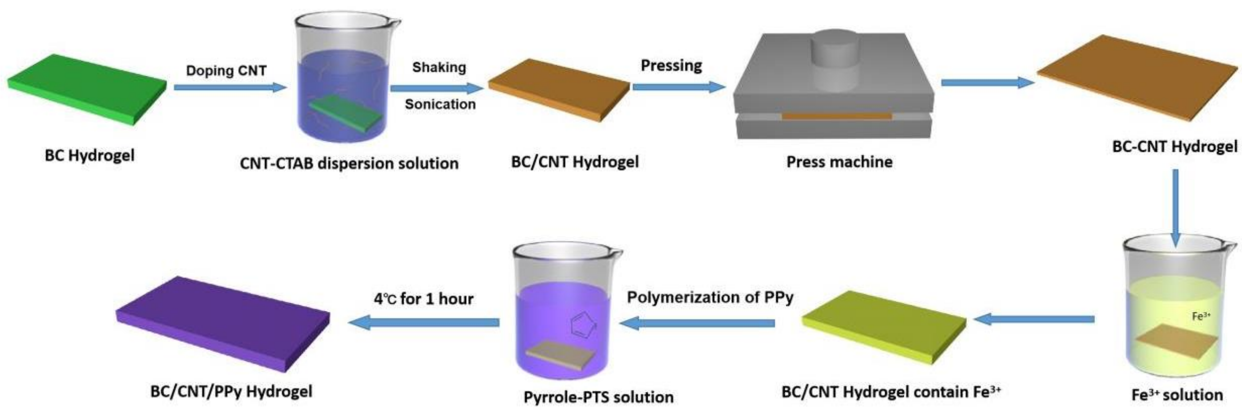


**Figure S1.** The schematic illustration of preparation process of BC/CNT and BC/CNT/PPy hydrogels.

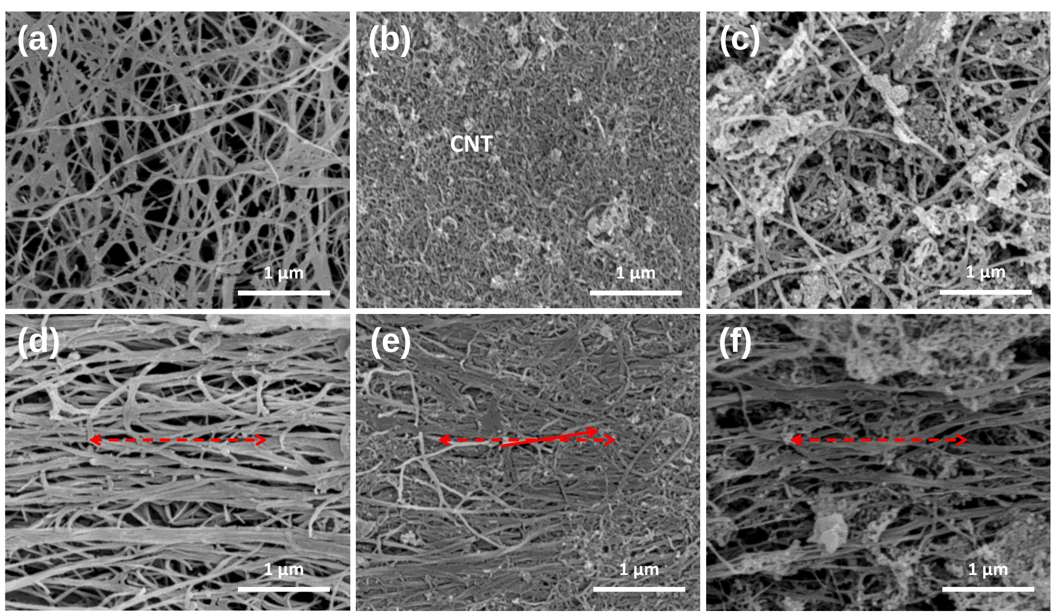


**Figure S2.** SEM images of pure BC, BC/CNT, BC/CNT/PPy hydrogel. The surface morphology of (a) BC, (b) BC/CNT, (c) BC/CNT/PPy, (d) stretched BC, (e) stretched BC/CNT, (f) stretched BC/CNT/PPy.

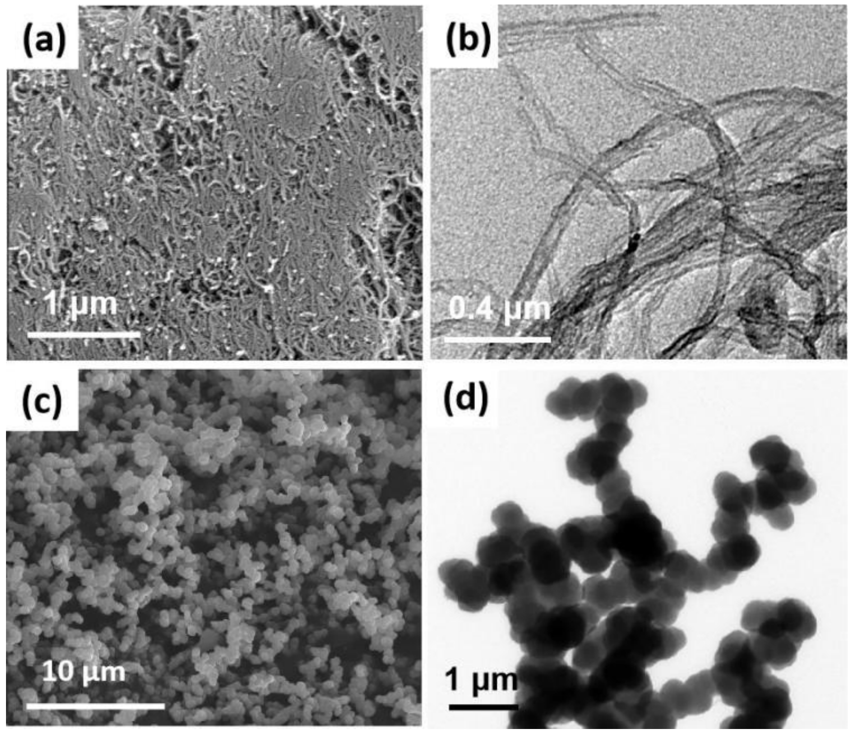


**Figure S3.** SEM images of (a) CNTs, (c) PPy. TEM images of (b) CNTs, (d) PPy.

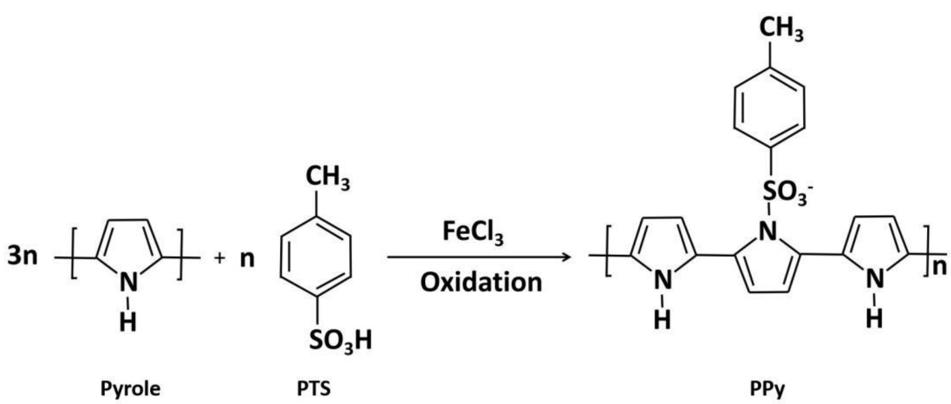


**Figure S4**. Synthesis mechanism of PPy with P-TSA as a dopant.

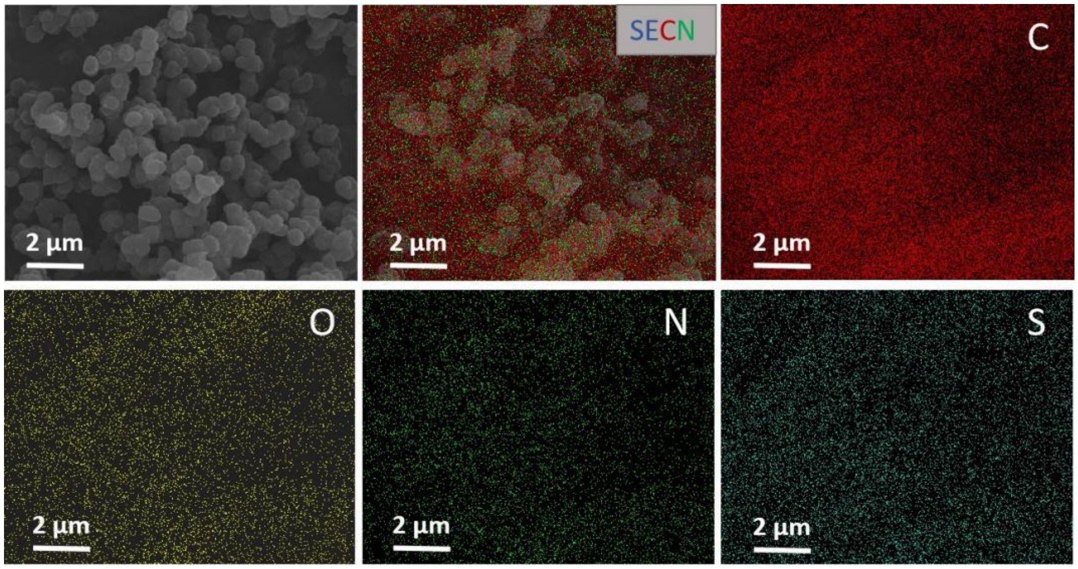


**Figure S5**. SEM of PPy particles and corresponding EDS elements are mapping for C, N, O, and S.

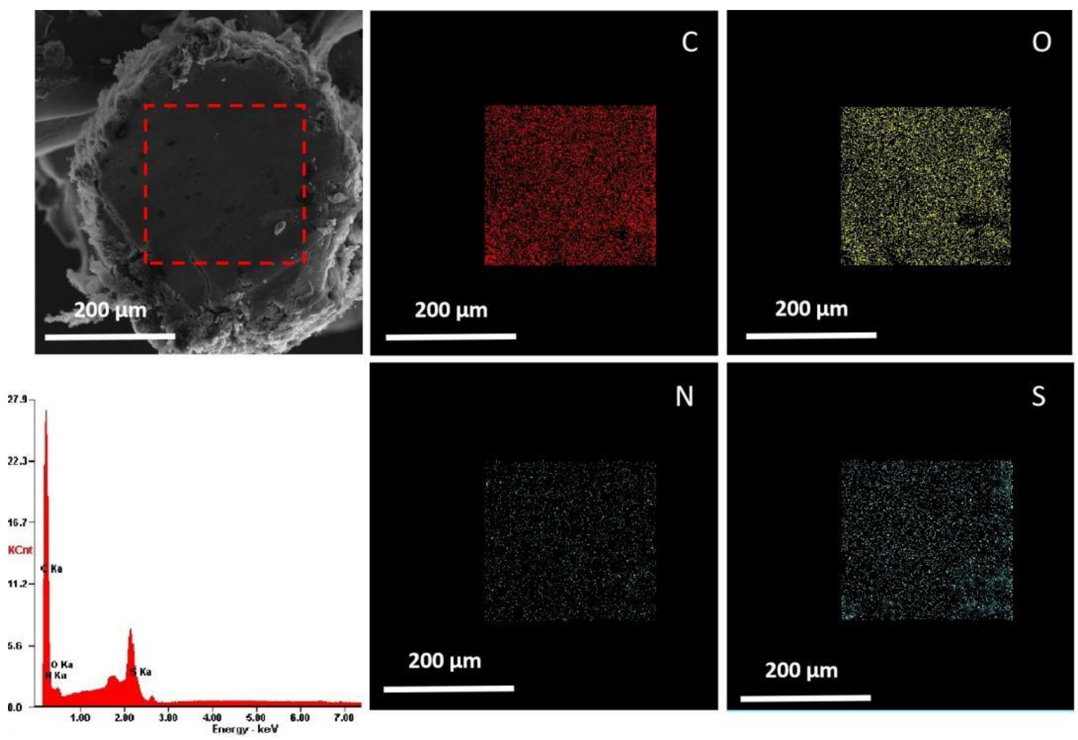


**Figure S6.** Fracture SEM of BC/CNT/PPy macrofibers and corresponding mapping for C, N, O, and S.

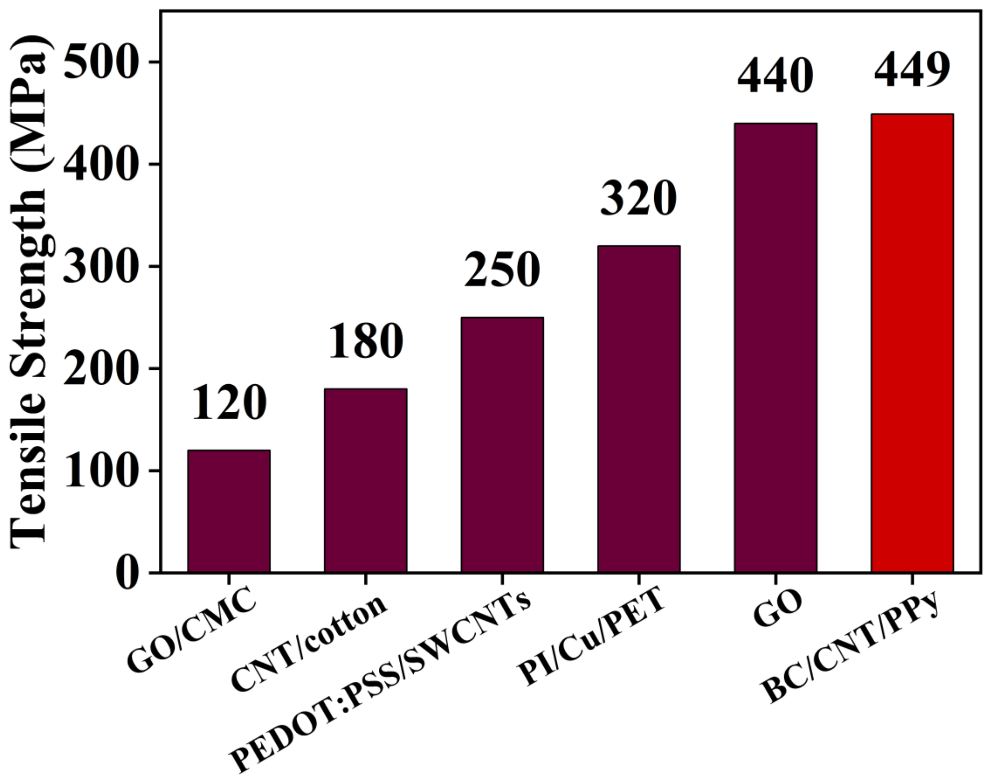


**Figure S7.** Comparison of tensiles strength of BC/CNT/PPy conductive macrofiber and other conductive macrofibers.

**Table S3.** Elementary Analysis of BC/CNT macrofibers, CNT content, Electrical Conductivity, Tensile strength and Young's modulus.

| Macrofibers | CNT content (wt%) | C (%) | H (%) | N (%) | CNT content (wt%) | Electrical Conductivity (S/cm) | Tensile strength (MPa) | Young's modulus (GPa) |
|---|---|---|---|---|---|---|---|---|
| BC | | 42.47 | 5.96 | 0.02 | 0 | 2E-13 | 825.7 ± 42.6 | 52.2 ± 0.92 |
| BC/CNT-1 | 0.025 | 43.23 | 6.14 | 0.00 | 2.36 | 0.65 ± 0.04 | 680.8 ± 47.1 | 45 ± 3.64 |
| BC/CNT-2 | 0.05 | 43.64 | 6.16 | 0.01 | 3.06 | 0.92 ± 0.03 | 671.4 ± 93 | 42.7 ± 4.26 |
| BC/CNT-3 | 0.1 | 44.10 | 6.13 | 0.01 | 3.86 | 1.59 ± 0.01 | 549.1 ± 40 | 28 ± 1.32 |
| BC/CNT-4 | 0.2 | 46.01 | 6.06 | 0.06 | 7.14 | 2.22 ± 0.12 | 487.1 ± 32 | 25.6 ± 0.8 |
| BC/CNT-5 | 0.3 | 46.8 | 6.04 | 0.05 | 8.5 | 1.72 ± 0.09 | 376.3 ± 55.7 | 12.5 ± 1.88 |

**Table S4.** Elementary Analysis of BC/CNT/PPy macrofibers, PPy content, Electrical Conductivity, Tensile strength and Young's modulus.

| Macrofibers | Conc of pyrrole (mol) | C (%) | N (%) | S (%) | PPy Content (wt%) | Electrical Conductivity (S/cm) | Tensile strength (MPa) | Young's modulus (GPa) |
|---|---|---|---|---|---|---|---|---|
| BC/CNT-4 | | 46.01 | 0.06 | 0.00 | 0 | 2.22 ± 0.12 | 487.1 ± 32 | 25.6 ± 0.8 |
| BC/CNT/PPy-1 | 0.01 | 44.04 | 1.00 | 0.27 | 3.03 | 2.53 ± 0.06 | 450.4 ± 14.7 | 35.6 ± 2.8 |
| BC/CNT/PPy-2 | 0.03 | 47.84 | 3.27 | 1.13 | 12.69 | 3.77 ± 0.24 | 515.9 ± 74.8 | 29.3 ± 0.08 |
| BC/CNT/PPy-3 | 0.05 | 49.11 | 4.44 | 2.06 | 23.14 | 5.32 ± 0.12 | 448.4 ± 29.3 | 19 ± 5.95 |
| BC/CNT/PPy-4 | 0.07 | 51.11 | 5.51 | 2.67 | 30 | 5.02 ± 0.37 | 317.1 ± 21.3 | 13.8 ± 2.24 |
| BC/CNT/PPy-5 | 0.09 | 48.58 | 4.92 | 2.38 | 26.74 | 5.45 ± 0.4 | 136.3 ± 26.3 | 5.1 ± 0.03 |

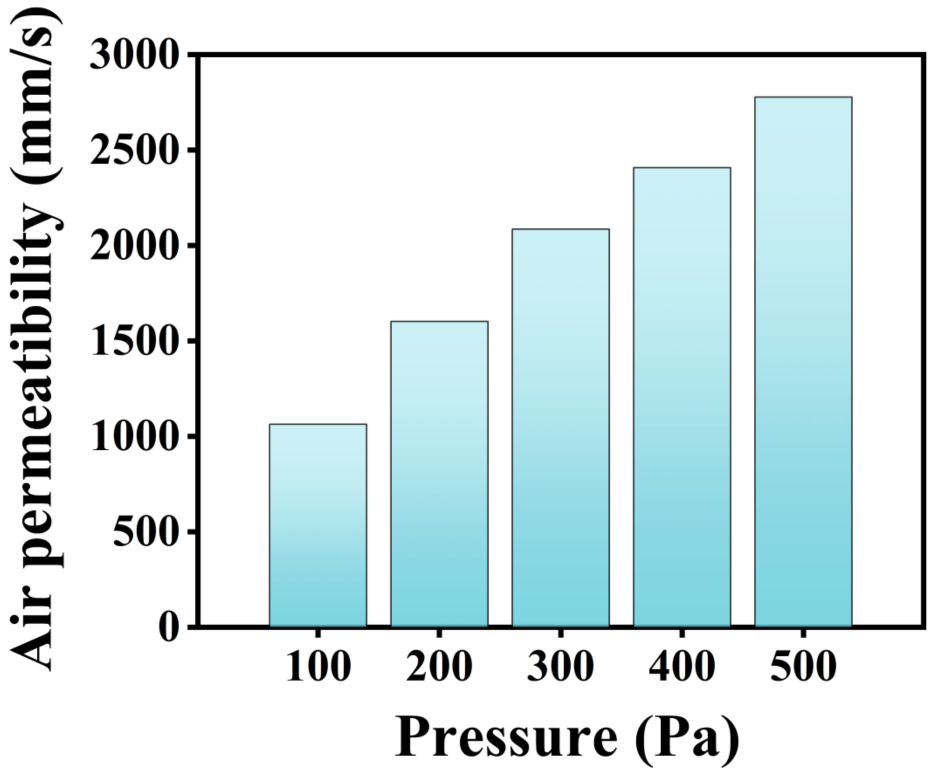


**Figure S8**. The air permeability of fabric-based TENG.

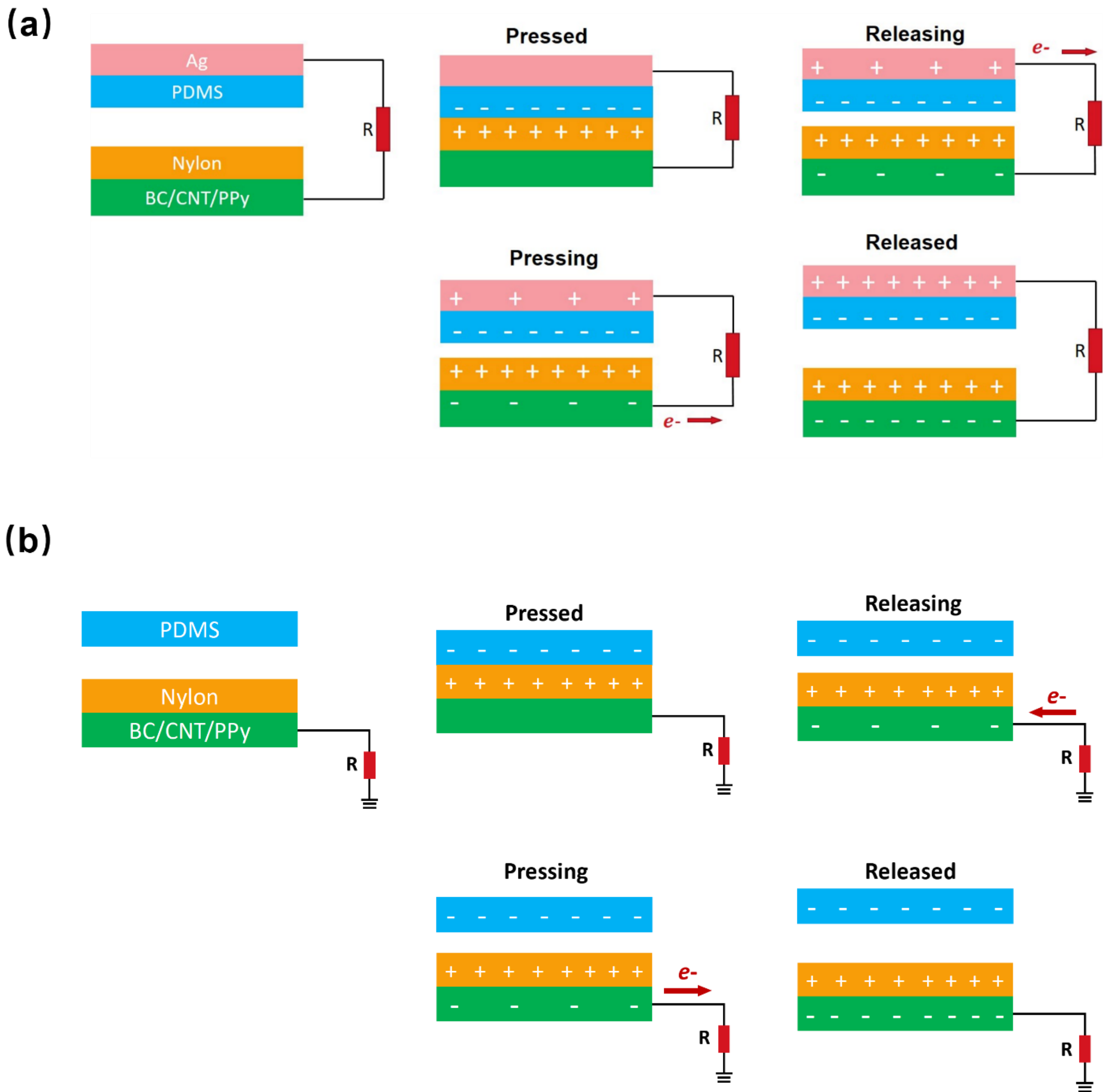


**Figure S9.** The energy-generating mechanism of the fabric-based TENG, (a) contact-separation mode and (b) single electrode mode.

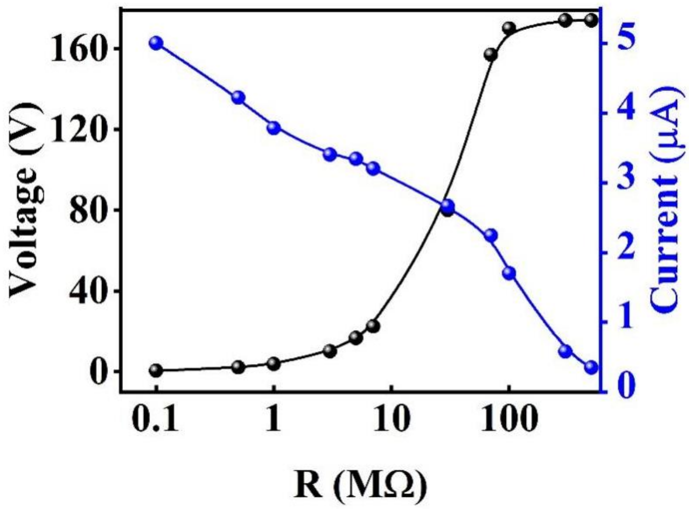


**Figure S10.** Relationship between current and voltage of the external load.

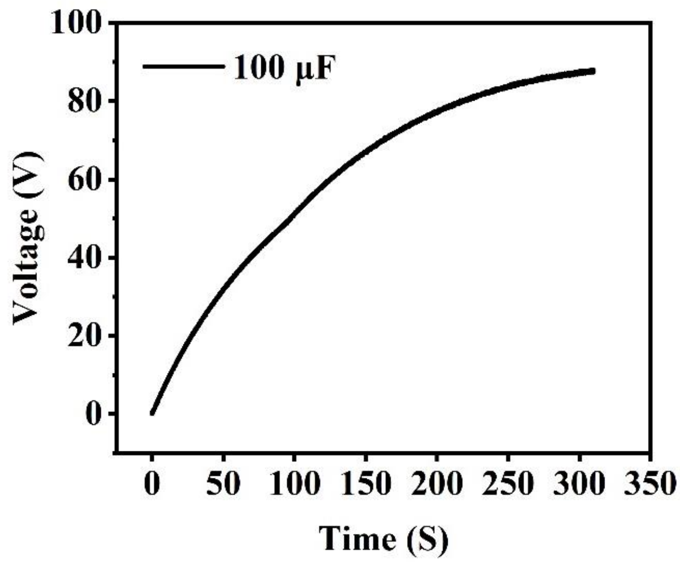


**Figure S11.** The charging curve of the 100 μF by pressing the fabric-based TENG at 4 Hz.