Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Single-electrode triboelectric nanogenerators based on sponge-like porous PTFE thin films for mechanical energy harvesting and self-powered electronics

Meng Wang, Nan Zhang, Yingjie Tang, Heng Zhang, Chuan Ning, Lan Tian, Weihan Li, Jiahao Zhang, Yanchao Mao,* Erjun Liang

MOE Key Laboratory of Materials Physics, School of Physical Science and Engineering, Zhengzhou University, Zhengzhou 450001, China

*Email: ymao@zzu.edu.cn

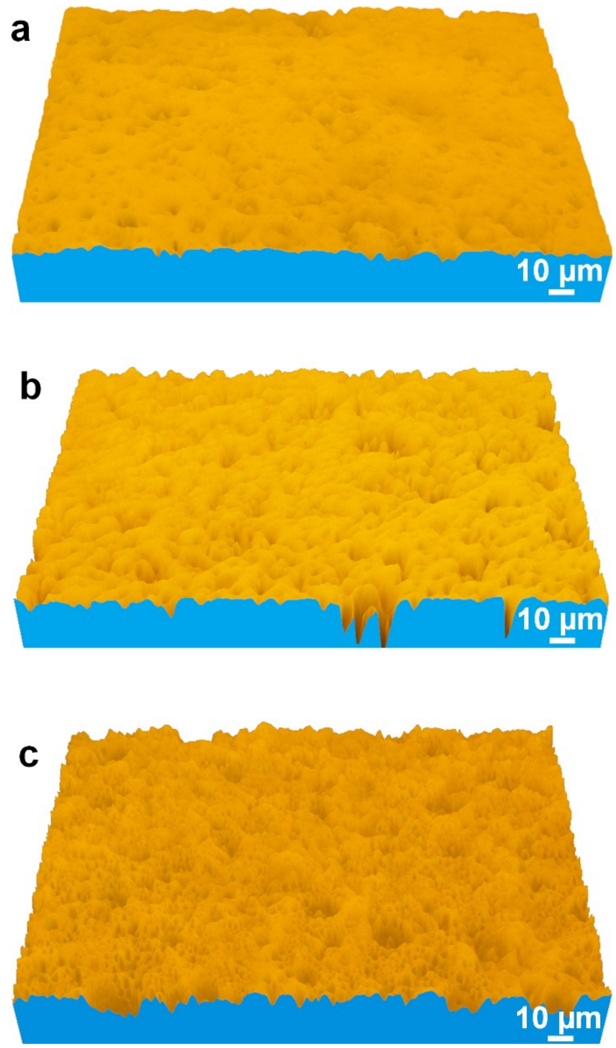

Fig. S1 3D optical microscope images of porous PTFE thin films prepared from mixtures with (a) 20%, (b) 50%, and (c) 80% DI water volume fraction, respectively.

Fig. S1 shows the 3D optical microscope images of the porous PTFE thin films fabricated from mixtures with 20%, 50%, and 80% DI water volume fraction, respectively. It is clearly shown that there are plenty of pores embed in all these PTFE thin films. And also more DI water in the mixture generated higher porosity in the porous PTFE thin film.

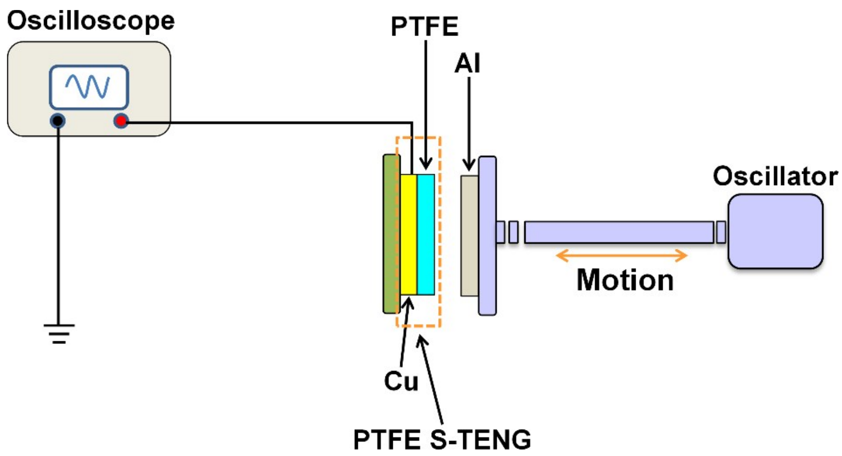

Fig. S2. Schematic setup for characterizing the PTFE S-TENG for harvesting mechanical energy from oscillations.

As schematically shown in Fig. S2, a porous PTFE S-TENG (2 cm × 2 cm × 20 μm) was attatched onto the surface of a fixed flat panel. An oscillator was used to impact the S-TENG with a certain frequency. A piece of Al foil was attached onto the vibrating broad of the oscillator. Driven by the oscillator, the Al foil could contact with the PTFE surface of the S-TENG with a controlled frequency. An oscilloscope was connected with the Cu electrode of the S-TENG to measure its electrical output signal. Another electrode of the oscilloscope was connected to ground.

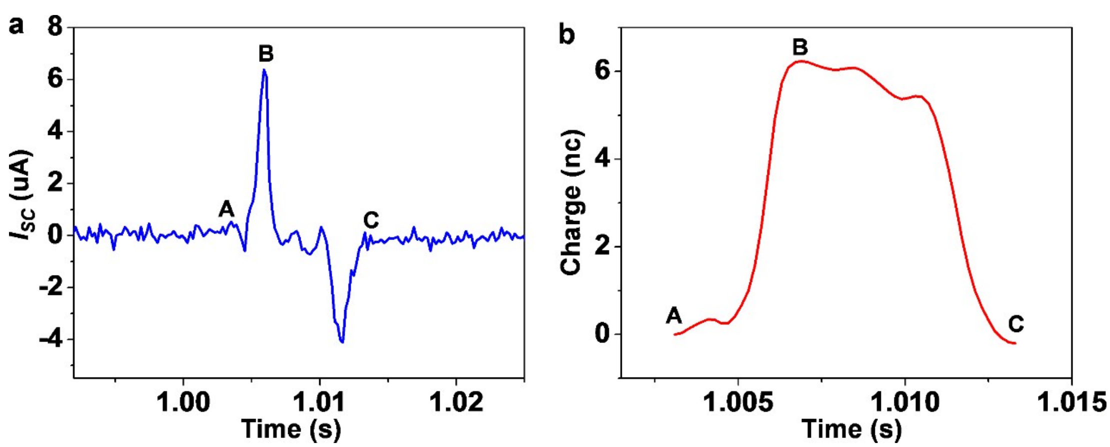

Fig. S3 (a) The output current generated from one contact-separation cycle of the porous PTFE S-TENG. (b) The corresponding output charge calculated from the integral area of the I-t curve in (a).

Fig. S3a shows the output current of a full contact-separation cycle. The point A, B, and C in Fig. S3a are consistent with initially contact, fully contact, and fully separation state of the porous

PTFE thin film and Al foil. The corresponding output charge (Fig. S3b) was calculated by the integral area of the I-t curve in Fig. S3a through the following equation:[1-4]

$$q = \int_{a}^{b} I \mathrm{d}t$$

where I is the output current, t is the time, [a, b] is the time interval, and q is the output charge. From point A to B, the output charge increased from 0 to 7.1 nC when the S-TENG initially contacting with Al foil to a fully contact state. After the electrical balance state at point B, the output charge almost decreased to zero at point C in the separating process. The output charge increasing and decreasing process are consistent with the positive and negative current generated in a contact-separation cycle, respectively. It also evidenced the working mechanism (shown in Fig. 2) of the porous PTFE S-TENG.

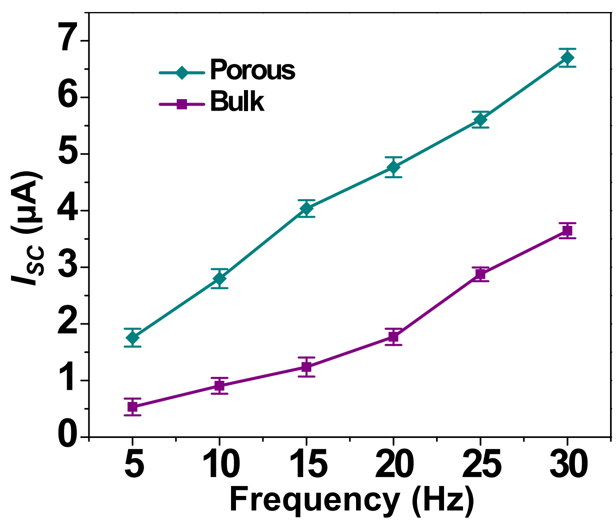

Fig. S4 Comparison of the peak I_{SC} between a porous PTFE thin film (50% DI water volume fraction) and a solid PTFE thin film under oscillation frequencies from 5 to 30 Hz.

The peak I_S of the porous PTFE thin film prepared by the 50% DI water volume fraction mixture and the solid PTFE thin film prepared by the mixture without DI water was exhibited in Fig. S4. The peak I_S both thin films increased with the frequency, which is similar to the tendency of the peak V_{OC} in Fig. 4c. As shown in Fig. S4, The peak I_S of the porous PTFE thin film is obtained to be 1.8 μA to 6.7 μA, which is over 1.8 times of the value for solid thin film (from 0.53 μA to 3.6 μA).

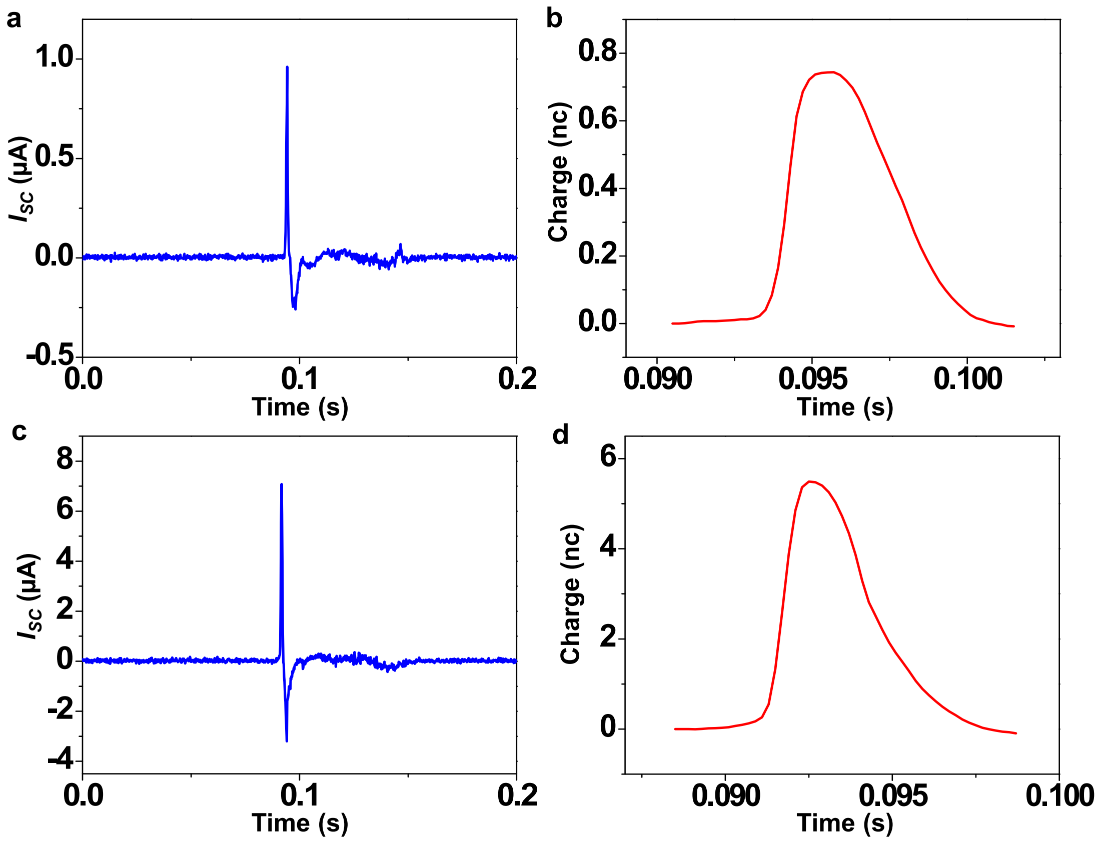

Fig. S5 The output current generated from one cycle of the porous PTFE S-TENG when pressed by (a) a human bare hand and (c) a human hand within latex glove. (b, d) The corresponding output charge calculated from the integral area of the I-t curve in (a) and (c), respectively.

The output charge of the porous PTFE S-TENG when pressed by a human bare hand and a human hand within latex glove was calculated by the integral area of the corresponding I-t curves as shown in Fig. S5. The porous PTFE S-TENG could generate 0.74 nC output charge when pressed by a human bare hand. When pressed by a human hand within latex glove, the output charge of the S-TENG could reach 5.5 nC.

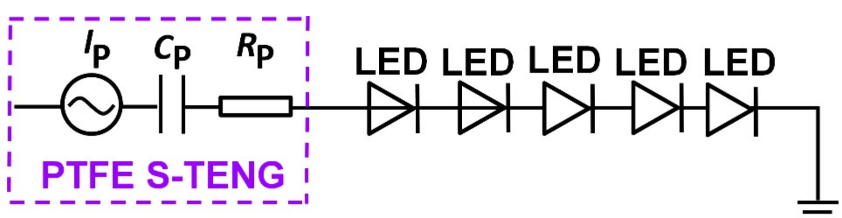

Fig. S6 The equivalent circuit for powering LEDs through porous PTFE S-TENG.

The equivalent circuit consists of the PTFE S-TENG, LEDs and the ground electrode. 5 commercial green LEDs was connected in series to be an array. One end of the LED array was connected to the Cu electrode of the PTFE S-TENG. Another end of the LED array is connected to ground. When the PTFE S-TENG was operated to generate electricity, its output current could flow through the LED array to the ground and instantaneously light up them.

Video S1 The output voltage of a porous PTFE S-TENG (4 cm × 4 cm), which was operated by a human hand within latex glove.

Video S2 5 commercial green LEDs were directly lighted up when the porous PTFE S-TENG was pressed by a human hand within latex glove.

References

1. J. Chen, H. Guo, X. He, G. Liu, Y. Xi, H. Shi and C. Hu, *ACS Applied Materials & Interfaces*, 2016, **8**, 736-744.
2. X. He, X. Mu, Q. Wen, Z. Wen, J. Yang, C. Hu and H. Shi, *Nano Research*, 2016, **9**, 3714-3724.
3. X. Xia, J. Chen, H. Guo, G. Liu, D. Wei, Y. Xi, X. Wang and C. Hu, *Nano Research*, 2017, **10**, 320-330.
4. Z. H. Lin, G. Cheng, L. Lin, S. Lee and Z. L. Wang, *Angewandte Chemie International Edition*, 2013, **52**, 12545-12549.