Electronic Supplementary Information

Inverting TENG to realize AC mode based on triboelectrification and air-breakdown

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Supplementary Figures

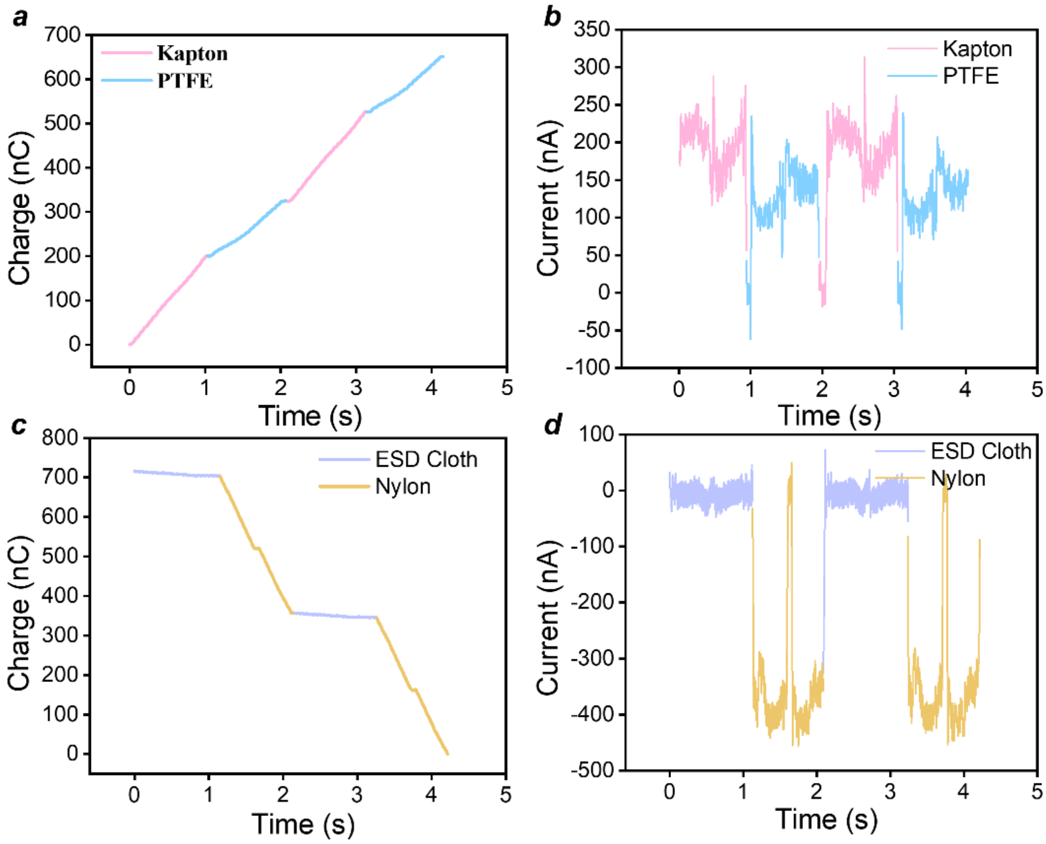

Fig. S1. The output performance of I-TENG under the same electricity polarity friction materials. a,b The output charge and current of I-TENG with a pair of negative electricity materials (Kapton and PTFE) and **c,d** a pair of positive electricity materials (ESD CLOTH and Nylon).

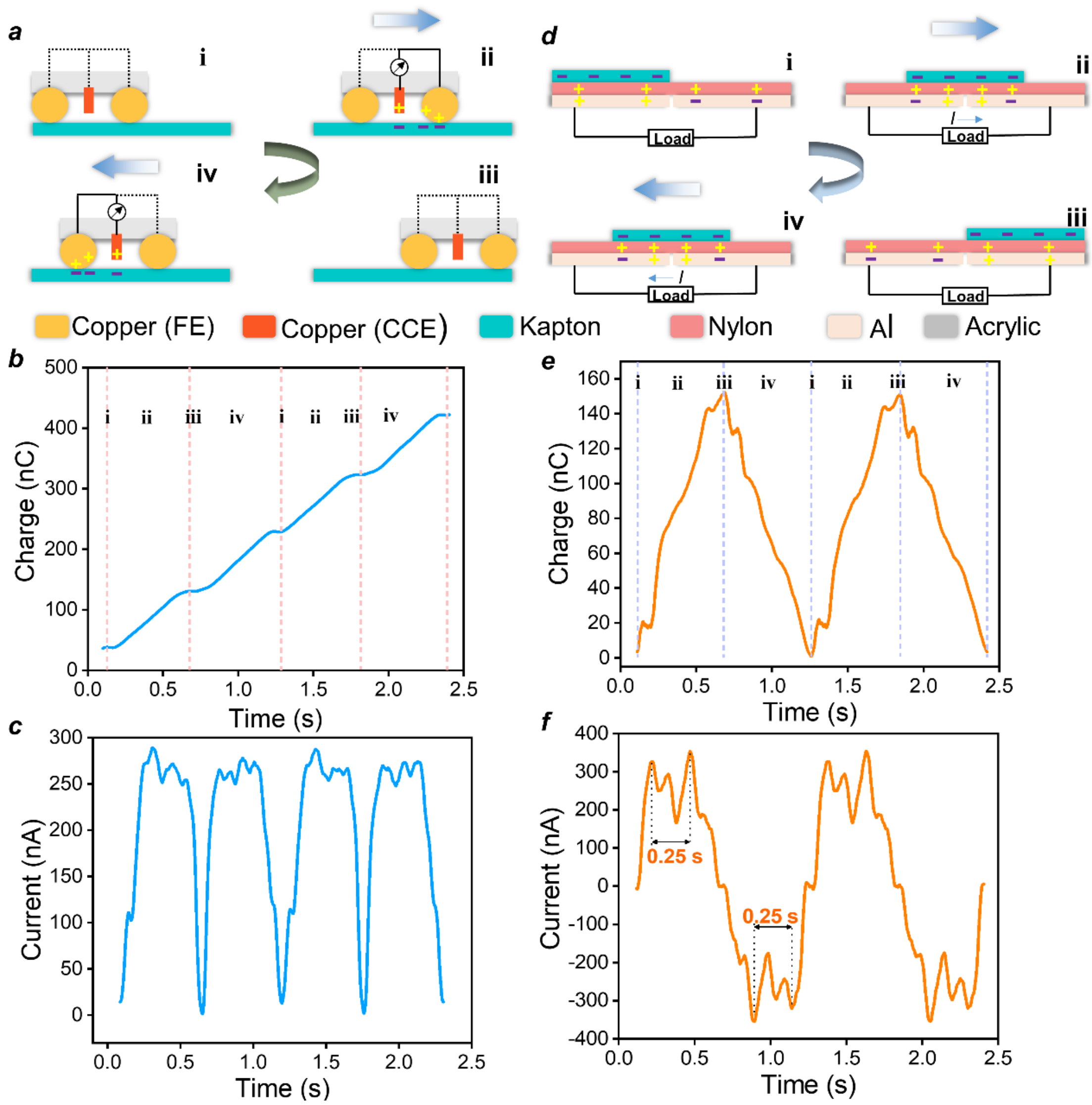

Fig. S2. The mechanism and output performance of DC-TENG and AC-TENG. a Working mechanism of DC-TENG in one cycle. b,c The output charge and current of DC-TENG. d Working mechanism of AC-TENG. e,f the output charge and current of AC-TENG.

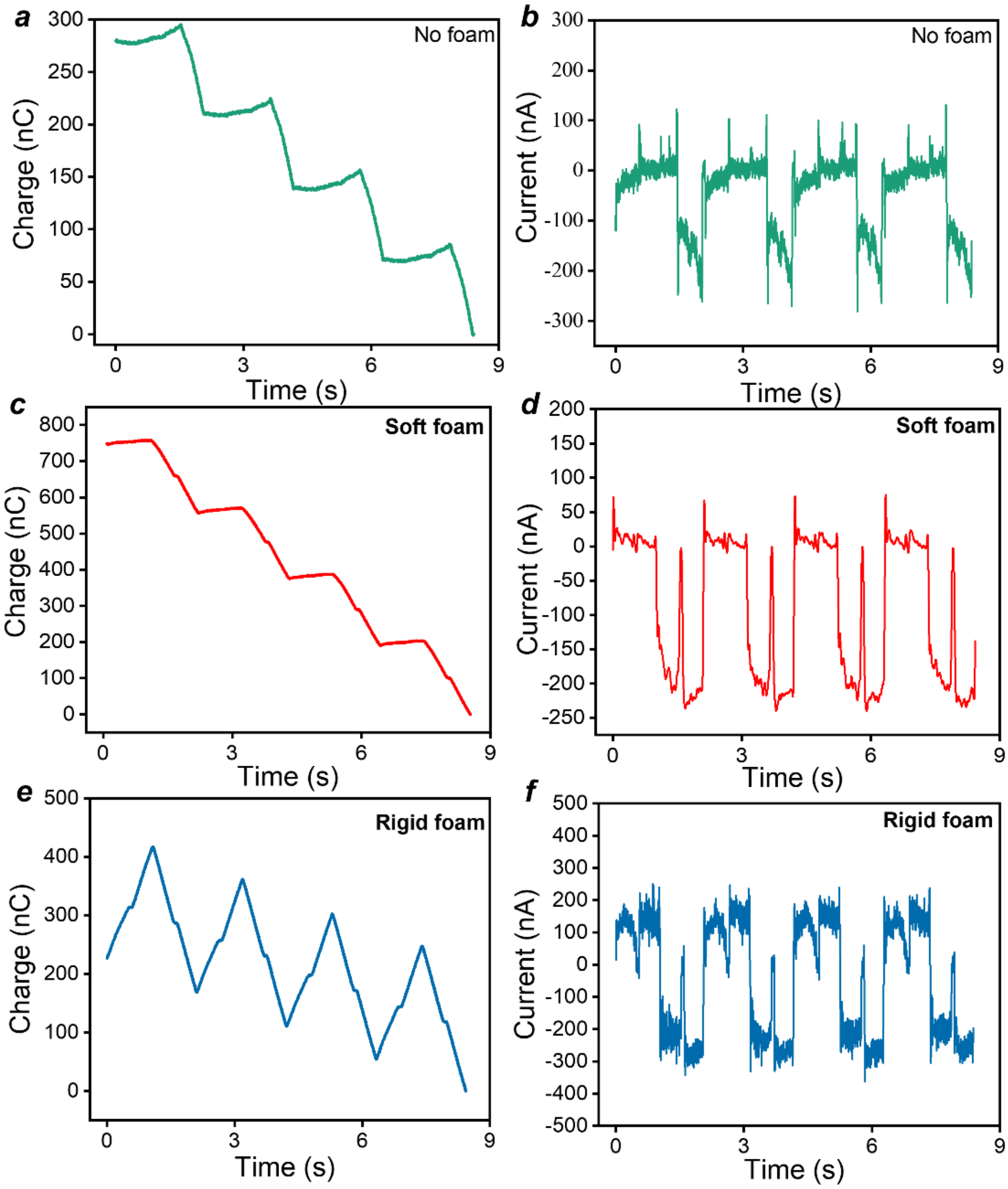

Fig. S3. The out performance of I-TENG with different buffer layers. The output charge and current of I-TENG, a, b without a foam and c,d with a soft foam as buffer layer. e,f with a rigid foam as buffer layer.

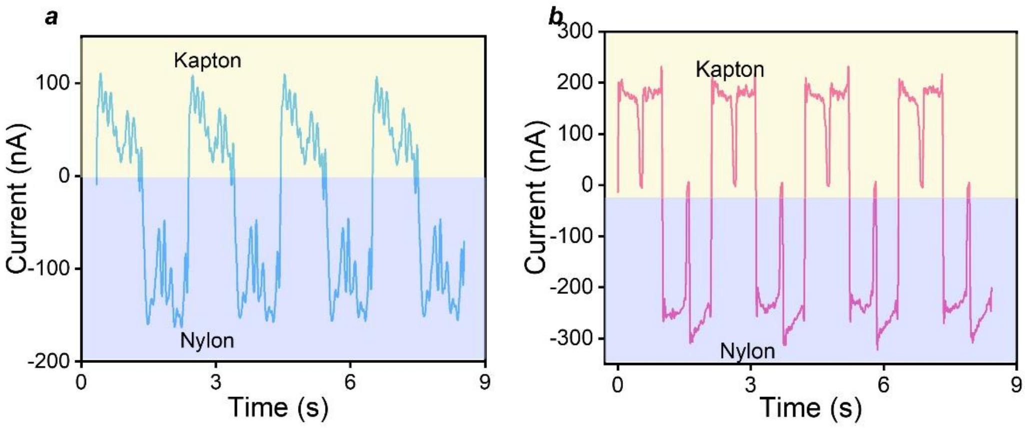

Fig. S4. The output current of I-TENG based different shapes of copper electrodes at the same experiment and structure parameters (except the FE). The current of I-TENG based **a** the copper foil and **b** copper rods as FE.

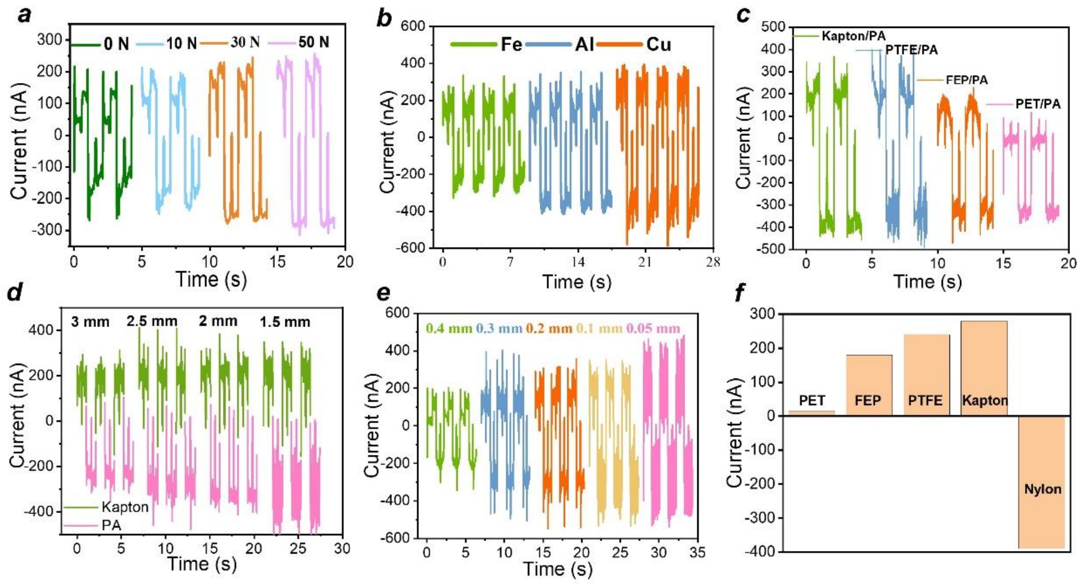

Fig. S5. Influence of structure parameters and material properties on the output performance of I-TENG. a Output current of I-TENG with a various applied forces, b different FE electrodes, c combining various negative electricity materials (Kapton, PTFE, FEP, PET) with positive electricity Nylon, d different electrode diameters, e various air gaps, f different dielectric friction layer materials.

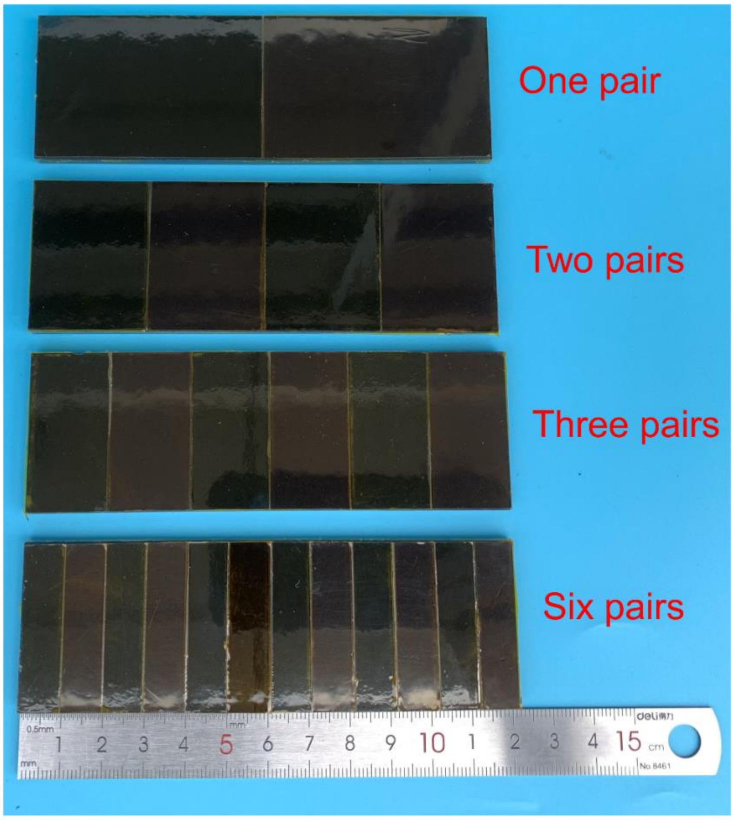

Fig. S6. The photograph of 1,2,3,6 pairs combine Kapton with nylon.

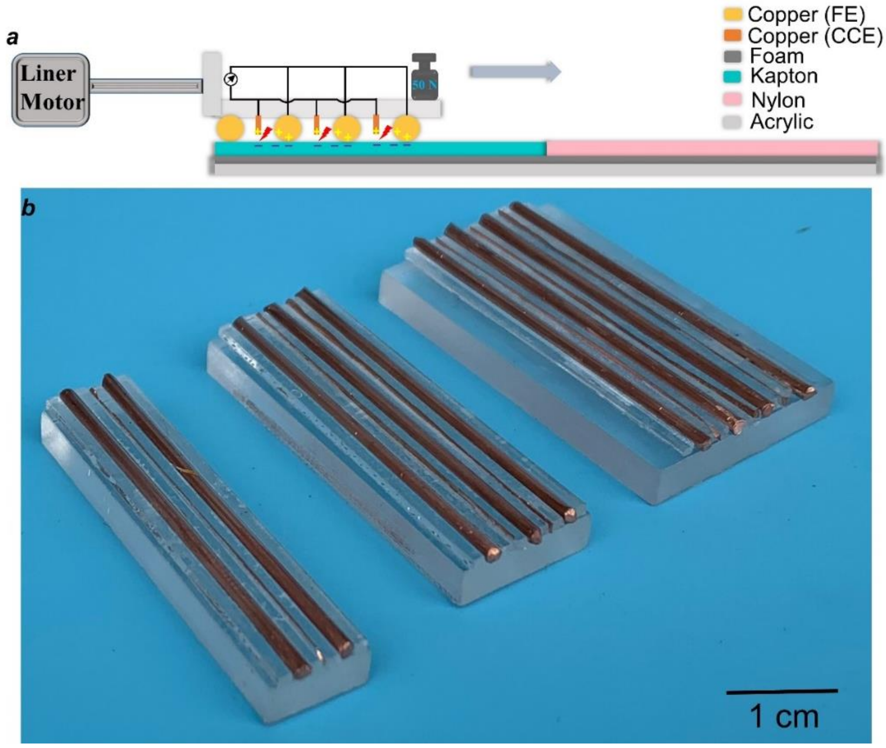

Fig. S7. The working mechanism and photograph of multiple pairs of electrodes.
a schematic diagram of 3 pairs electrodes I-TENG while running on the kapton film.
b Photograph of I-TENG with 1,2,3 pairs of electrodes.

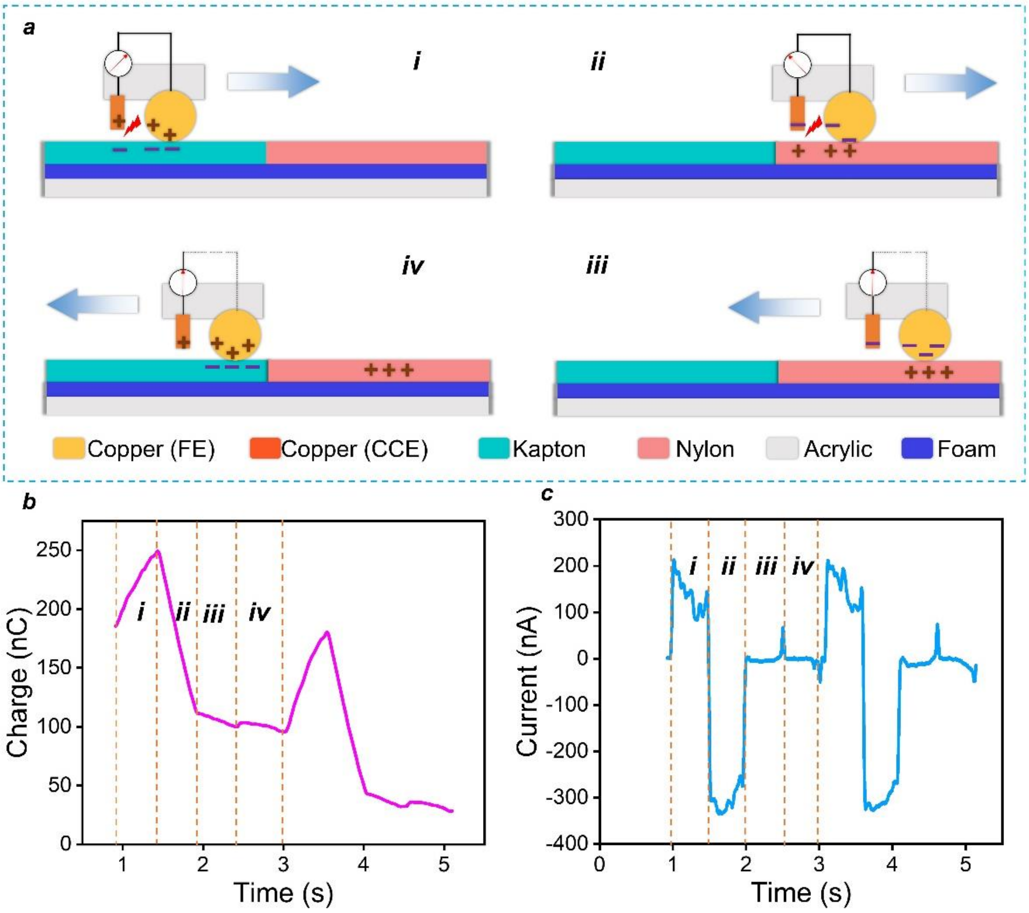

Fig. S8. The output performance of one friction electrode TENG. a The autal photograph of one friction electrode TENG. The working mechanism **(b)** of one friction electrode TENG and corresponding charge output **(c)** and current output **(d)**. When the FE crosses the conjunction from Nylon to Kapton, although Kapton is electronegative material, the electric potential is still higher than that of FE due to the accumulated negative charge on the FE. Therefore, there is negative charge transfer from the FE to Kapton, which results in a small pulse current as shown in Fig. S8c.

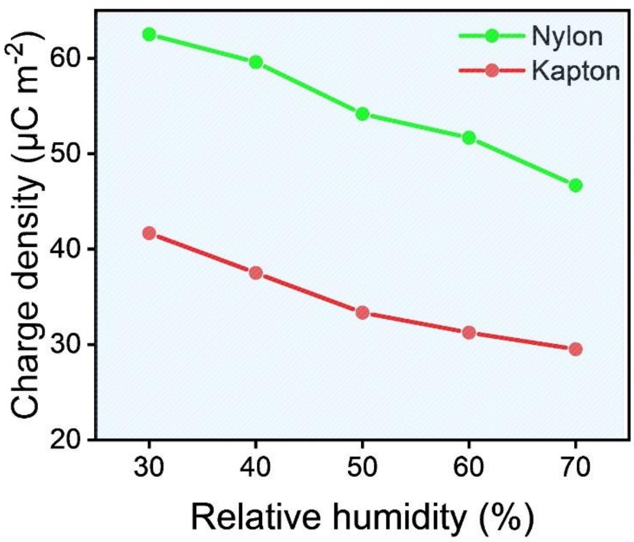

Fig. S9. Output charge density of CE-TENG when varying atmospheric relative humidity.

Supplementary Notes

Note S1: Working mechanism of DC-TENG

The working mechanism of DC-TENG was shown in **Fig. S2a**, which corresponds to the output signal step of **Fig. S2b**. Firstly, because existence of contact electrification, there are negative charge on the Kapton surface and identical number positive charge on the FE surface **(Fig. S2a[i])**. Under the linear motor driving, the friction electrode starts to move rightward, As long as there is a proper gap distance between the CCE and the friction layer to promote the generation of an high electrostatic field that is greater than dielectric strength of the air between them, thereby air is ionized, which attribute electrons transfer from Kapton layer to CCE, it cause potential difference decreasing between CCE and right FE, and finally current generation in the external circuit **(Fig. S2a[ii])**. The discharging process will stop temporarily When the right FE moves to the rightmost edge of kapton **(Fig. S2a[iii])**. Similarly, when electrodes move to backward, electrons will transfer Kapton to CCE, finally to left FE, thereby current generate in the external circuit **(Fig. S2a[iv])**. This will result in a constant DC output as long as the motion continues to execute.

Note S2: Working mechanism for traditional AC-TENG

Fig. S2d shows the working principle of traditional AC-TENG, in which Kapton as separate layer and the nylon completely cover two separate aluminum electrodes. When the Kapton and Nylon contact, positive charge on Nylon and negative charge on Kapton are formed based contact electrification, meanwhile there is no potential difference in the two aluminum electrodes without sliding distance **(Fig. S2d[i])**. When Kapton moves rightward, the charge will move from the left electrode to the right electrode in the external circuit **(Fig. S2d [ii])**. When Kapton and the right electrode coincide in exactly the same position, charge transfer ceases and all positive charges are moved to the right electrode **(Fig. S2d [iii])**. Subsequently, when kapton moves to the left along the nylon, there is a reverse charge movement in the external circuit, forming an AC output **Fig. S2d[iv])**.

Other Supplementary Material for this work includes the following:

Movie S1. (.mp4 format). The charge output of I-TENG can be formed by air-breakdown on two different electric polarity tribo-materials.

Movie S2. (.mp4 format). The alternating current output of I-TENG can be formed by air-breakdown on two different electric polarity tribo-materials.

Movie S3. (.mp4 format). More 200 LEDs are lighted up by I-TENG on both tribo-materials with hand power.

Movie S4. Real-time computer-simulated displacement and direction sensor for car monitoring and control.