# Capacitor-inspired high-performance and durable moist-electric generator

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Movie S1. CMEG connected together to power a calculator

Movie S2. CMEG is used as self-power sensors in moist sensing and touch sensing.

**Numerical simulation**

The ion diffusion process and the corresponding induced concentration difference on electrode surface under constant moisture feeding was simulated by a theoretical model based on Nernst-Planck equations and Butler-Volmer equations with proper boundary conditions.

$$\frac{\partial c_i}{\partial t} + \nabla j_i + u \cdot \nabla c_i = R_i$$

$$\nabla \cdot i_l = F\sum_i z_i R_i + Q_l$$

$$\nabla \cdot i_s = - F\sum_i z_i R_i + Q_s$$

$$J_i = - D_i \nabla c_i - z_i u_{m'} iFc_i \nabla \phi_l$$

$$i_l = - \sigma_l \nabla \phi_l$$

$$i_s = - \sigma_s \nabla \phi_s$$

where $\phi$, F, z, c, D, j, u, $\sigma$, and R represented the electrical potential, Faraday constant, valence of ionic species, ion concentration, diffusion coefficient, molar flux relative to the convective transport, velocity vector, surface ch, and ideal gas constant, respectively.

In this case, the diffusion coefficient is $1.54\times10^{-9}$ $m^2/s$ and $1.33\times10^{-9}$ $m^2/s$ for R-$SO_3^-$ and $Na^+$, the dielectric constant is 20. The initial ion concentration is set to be 250 $mol/m^3$ which was obtained by estimate the water content and electrolyte content in the fiber membrane from experiment result (12 w% water conetent, 20% electrolyte conetnt in nanofiber with 5% release under moisture), respectively. The boundary condition for anode and cathode electrode surface was described by:

$$\int_{\partial\Omega} i_l \cdot n dl = i_{l'} average \int_{\partial\Omega} dl$$

$$n \cdot i_l = i_{total}$$

$$i_{total} = \sum_{m} i_{loc,m} + i_{dl}$$

$$-n \cdot J_i = R_{i,tot}, \quad R_{i,tot} = \sum_{m} R_{i,m} + R_{dl,i}$$

and

$$n \cdot i_l = i_{total}$$

$$i_{total} = \sum_{m} i_{loc,m} + i_{dl}$$

$$-n \cdot J_i = R_{i,tot}, \quad R_{i,tot} = \sum_{m} R_{i,m} + R_{dl,i}$$

The top ITO electrode is set to zero potential, and the bottom zinc electrode, according to the experimental results in Figure 2c is set as 1 V. The calculations for the ionic diffusion process and the corresponding induced concentration difference on electrode surface were performed by commercial software Comsol Multiphysics, more specific parameter detials can find from Table S1. (version 6.0).

Table S1 Numerical simulation parameter details

| | Value | Description |
|---|---|---|
| $c_{Na^+}$ | 250 mol/m³ | initial ion concentration of $Na^+$ |
| $c_{HSO_3^-}$ | 250 mol/m³ | initial ion concentration of $HSO_3^-$ |
| $D_{Na^+}$ | 1.33E-9 m²/s | diffusion coefficient of $Na^+$ |
| $D_{HSO_3^-}$ | 1.54E-9 m²/s | diffusion coefficient of $HSO_3^-$ |
| $E_{neg}$ | -0.017919 V | initial negative potential |
| $E_{pos}$ | 1 V | initial positive potential |
| $E_{eq}$ | 1 V | equilibrium potential, positive main electrode reaction |
| $k_{Na}$ | 2.1E-7 m/s | the rate constant of the negative electrode reaction |
| $k_{HSO_3^-}$ | 2.5E-7 m/s | the rate constant of the positive electrode reaction |
| $K_{net}$ | 4.5E-8 mol/(m²·s) | negative rate constant |
| $K_{pos}$ | 0.0045 mol/(m²·s) | positive rate constant |
| L | 0.1 cm | thickness |
| T | 300 K | temperature |
| $t_{charge}$ | 3600 s | charging time |
| $t_{discharge}$ | 3600 s | discharging time |
| $t_{rest}$ | 60 s | rest time |

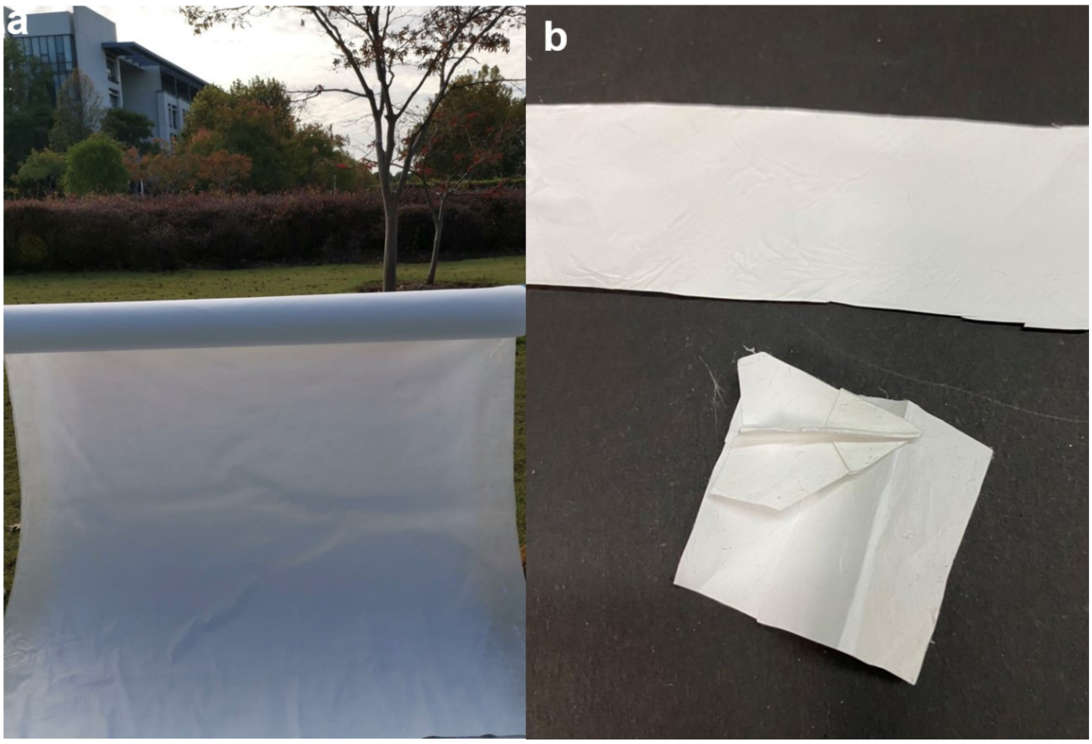


**Figure S1.** (a) Large-scale electrospun nanofiber film obtained by free-surface electrospinning indicating its low cost. (b) The electrospun nanofiber film can be fold into a paper airplane indicating its softness.

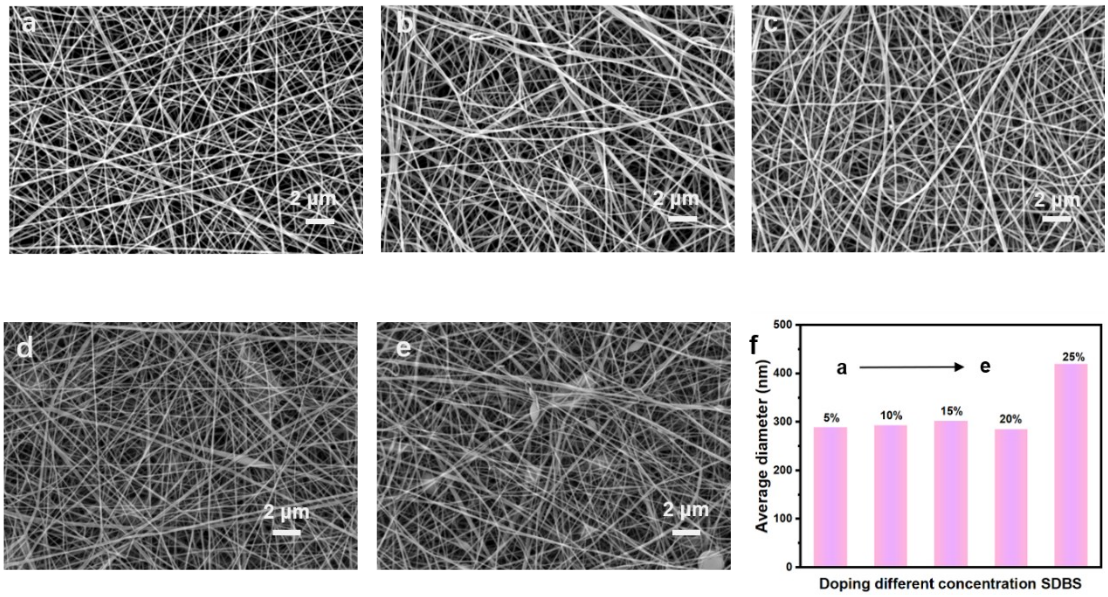


**Figure S2.** SEM image of doping different concentration SDBS. (a) 5%, (b) 10%, (c) 15%, (d) 20% (e) 25%. And their average diameter (f).

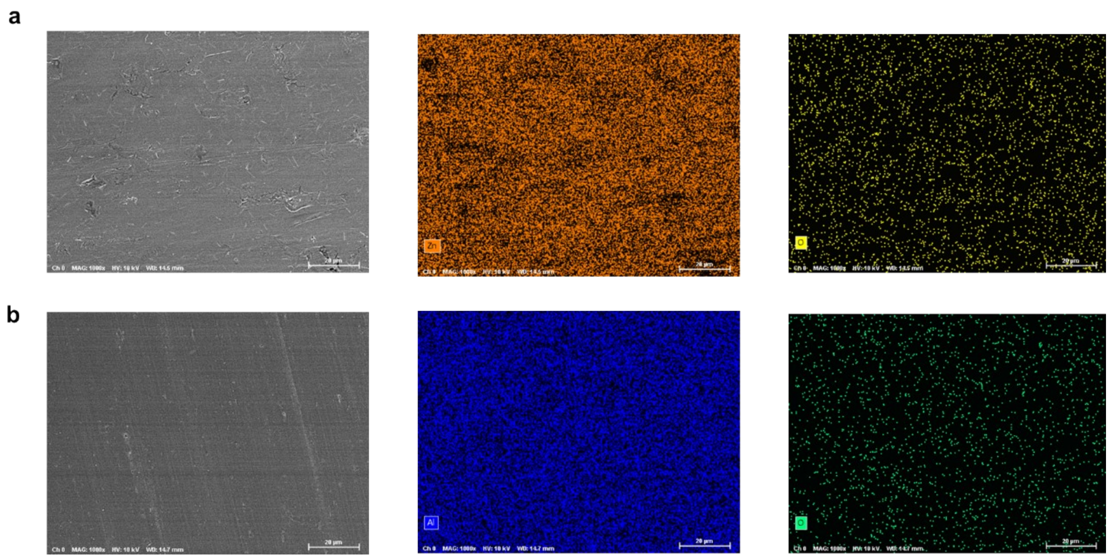


**Figure S3.** SEM images of the Zn (a) and Al (b) electrode and its EDS map of Zn, Al and O elements.

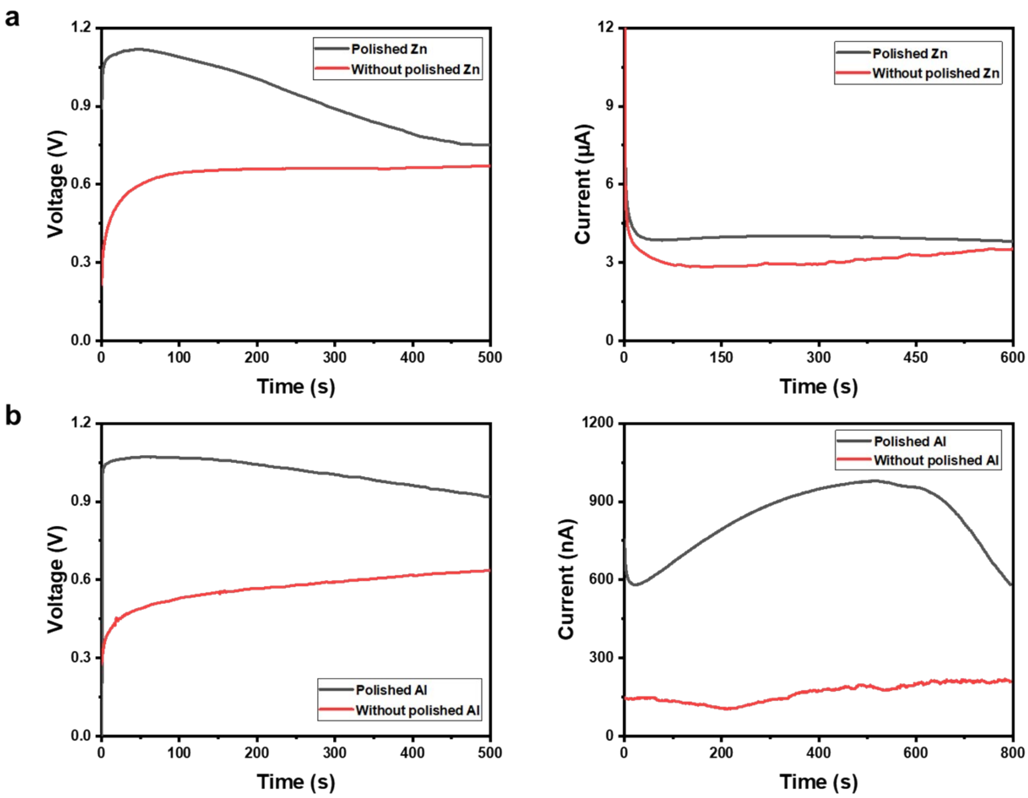


**Figure S4.** Voltage and Current output of (a) Zn and (b) Al electrode treated with polished or without polished.

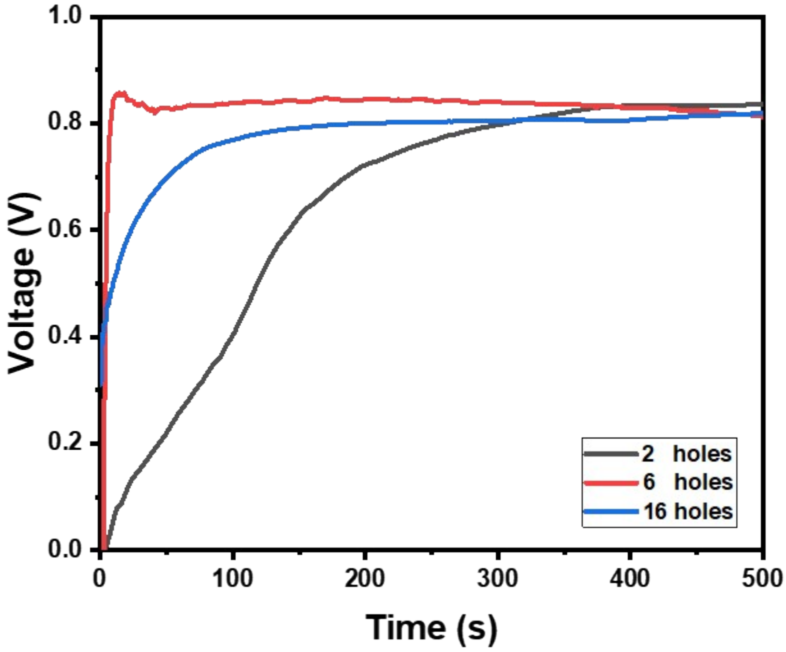


**Figure S5.** Voltage output of changing top ITO electrode with different number of holes.

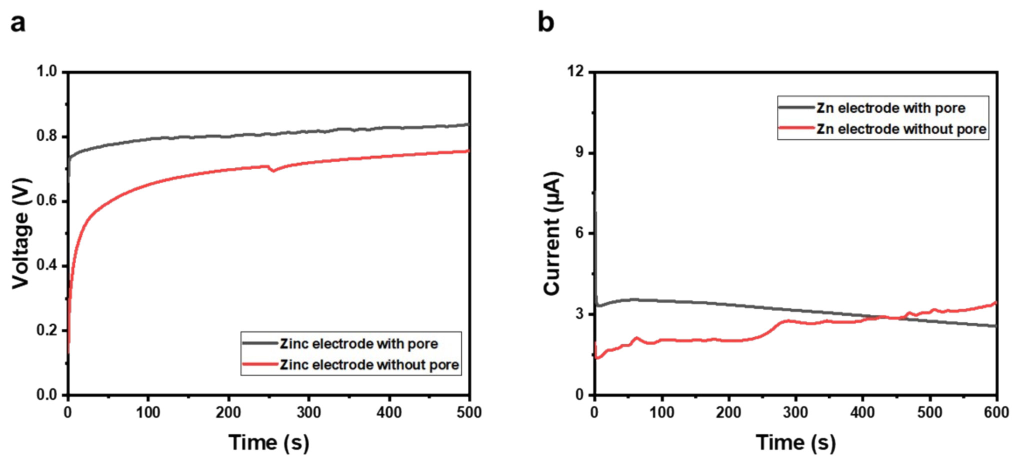


**Figure S6**. Voltage (a) and Current (b) output of bottom Zn electrode with pore or without pore.

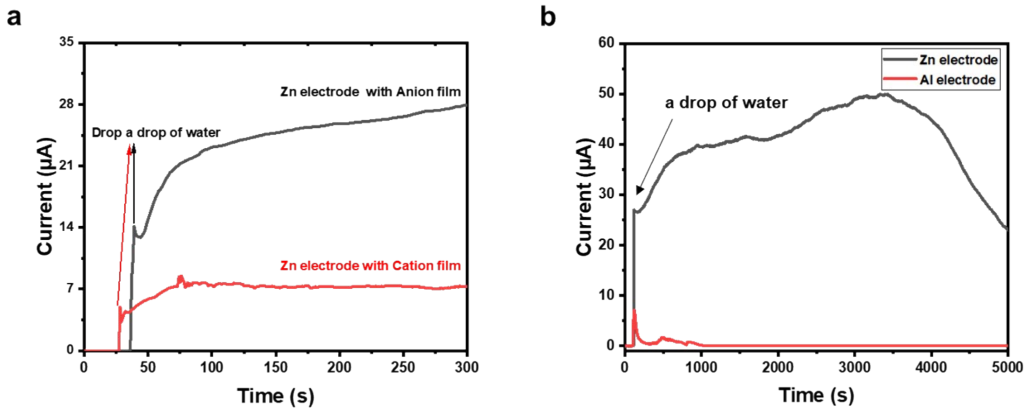


**Figure S7.** Current output of drop a drop of water to Zn electrode system device for short-term (a) and long-term test of anion doped film applied to different type of electrodes (b).

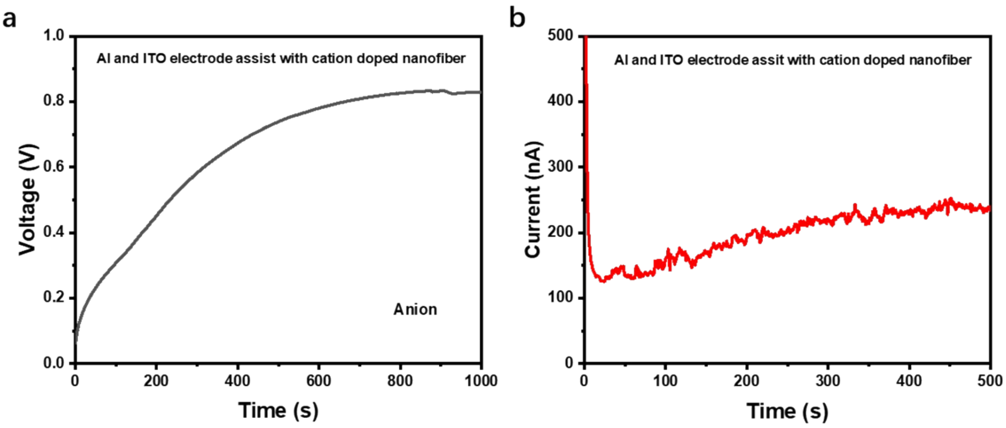


**Figure S8.** Voltage(a) and Current (b) output of CMEG when assembled with Al, ITO electrode and cation type electrode loaded nanofiber.

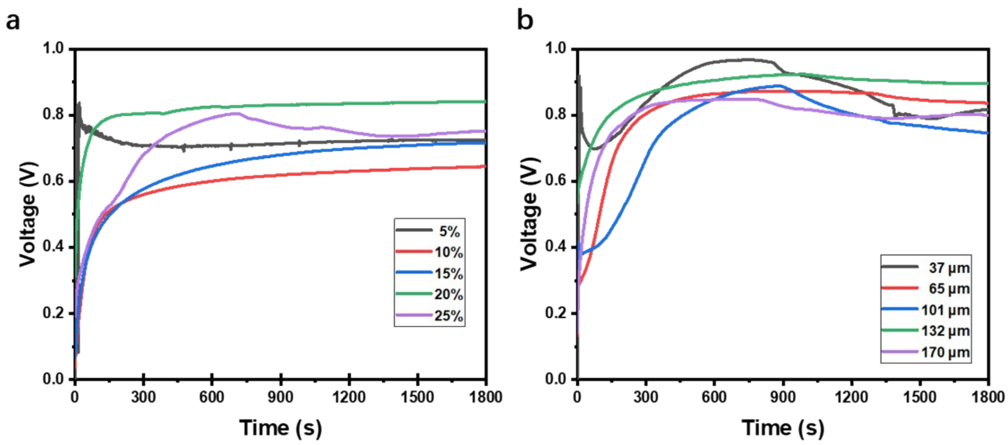


**Figure S9.** Voltage output of doping different concentration SDBS (a), and using different thickness PAN/SDBS (b).

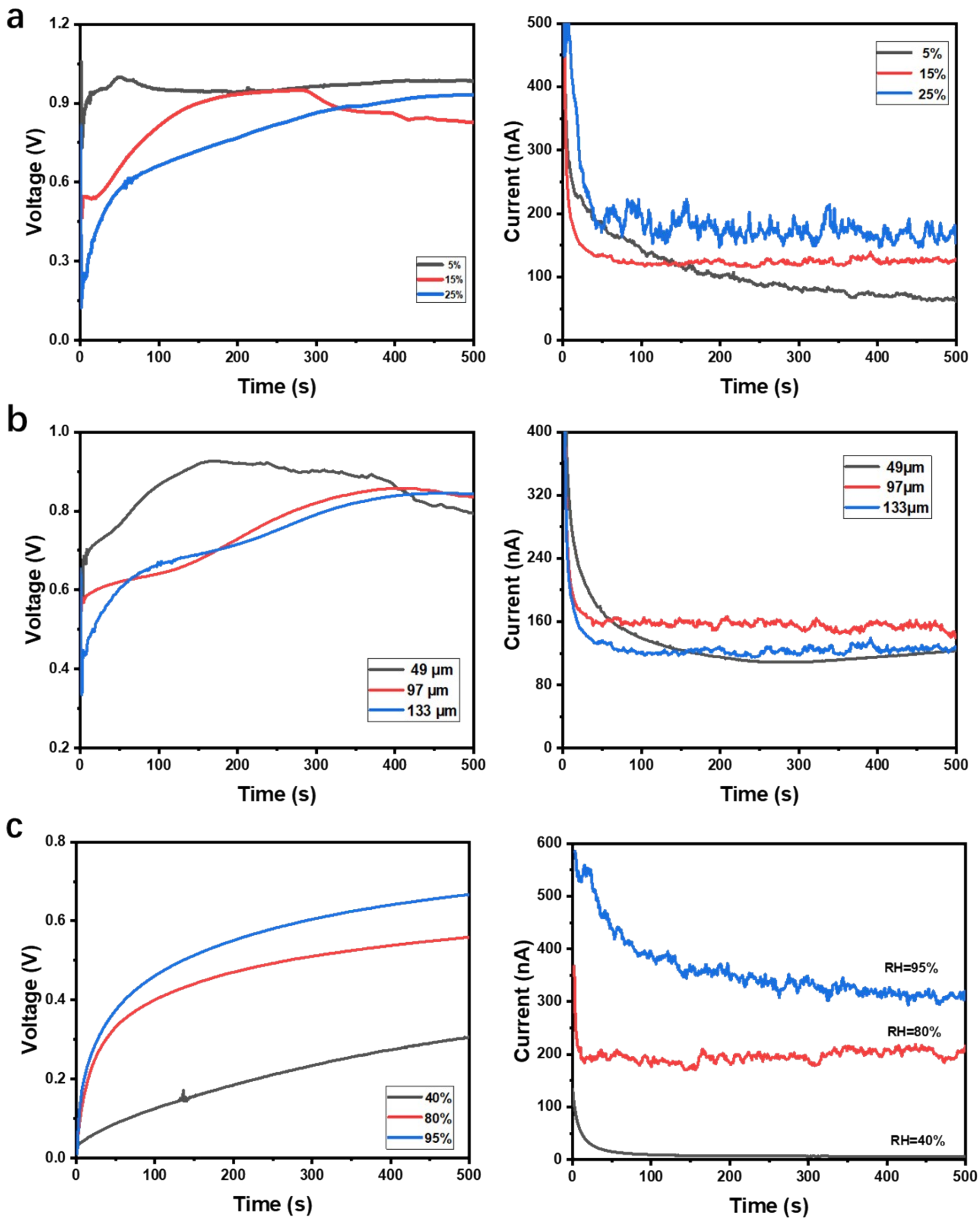


**Figure S10.** Voltage and Current output of different influence on Al and cation electrolyte (DTAB) system. (a) different concentration DTAB, (b) different PAN/DTAB nanofiber film thickness, (c) applied different humidity.

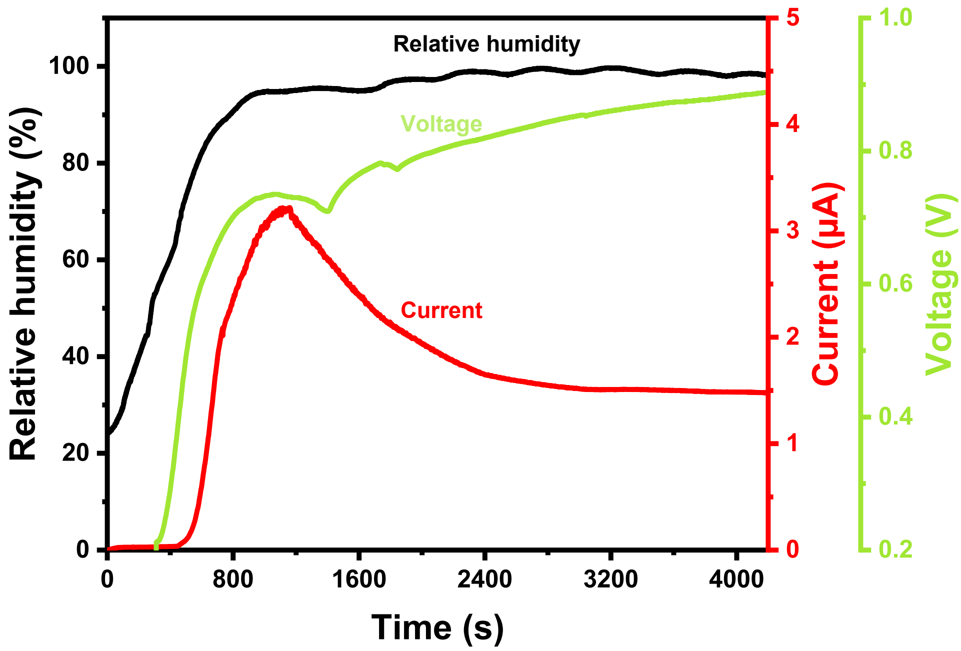


**Figure S11.** The measured voltage and current output of the device under a changing humidity.

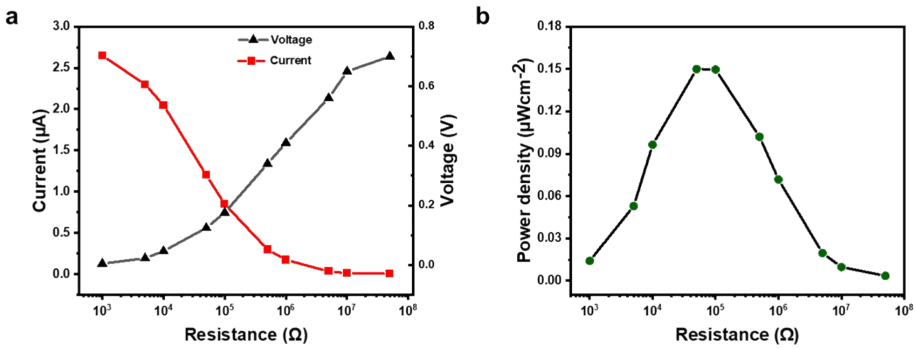


**Figure S12.** Current and voltage change with different load resistance for the device which has a working area of 1 $cm^2$ (a) and corresponding output power density (b).

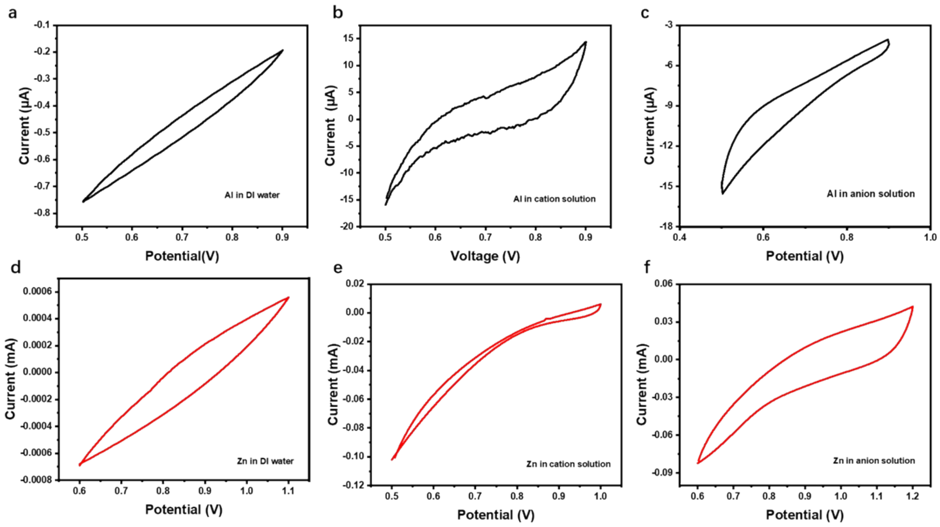


**Figure S13.** CV curves of different electrode in different solution. (a-c) Al electrode and ITO electrode system in DI water and SDBS/DTAB solution (0.5mol/L), scan rate 30 mV/s. (d-f) Zn electrode and ITO electrode system in DI water and SDBS/DTAB solution (0.5mol/L), scan rate 30 mV/s.

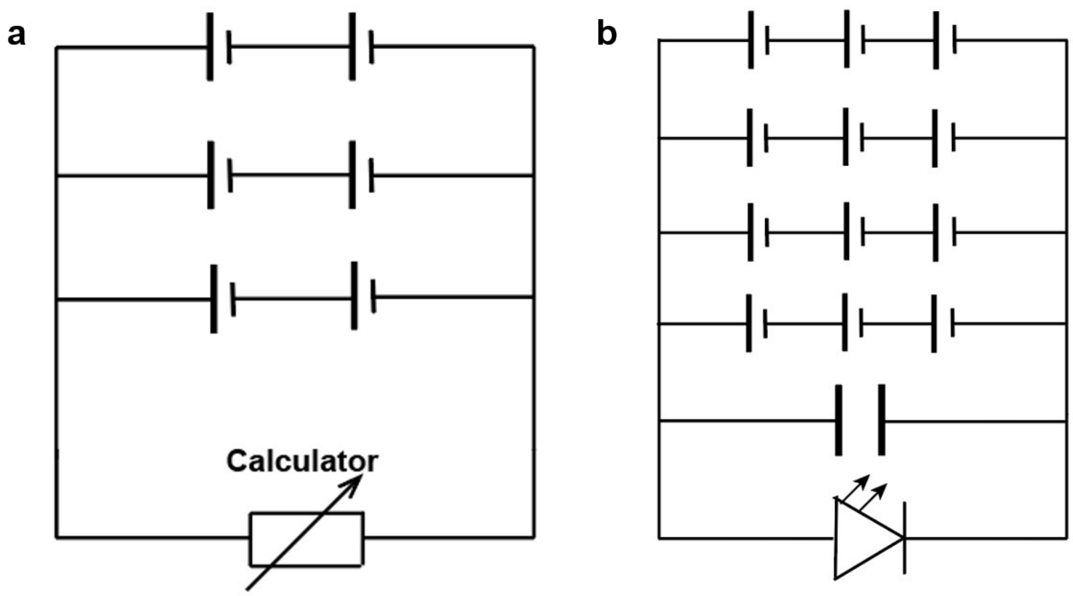


**Figure S14.** Circuit diagram for power calculator and LED light, (a ) power a calculator, (b) power a LED light.

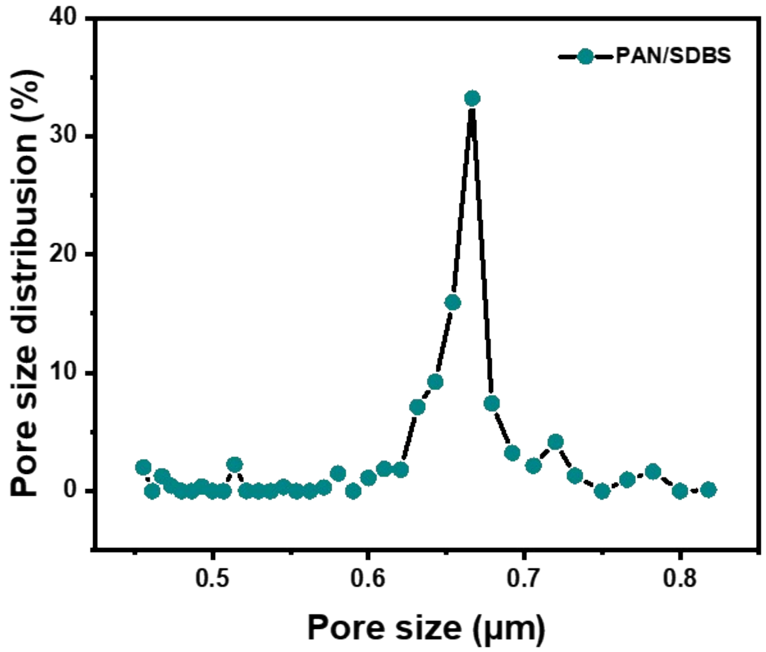


**Figure S15.** Pore size distribution of PAN/SDBS electrospun nanofiber film.

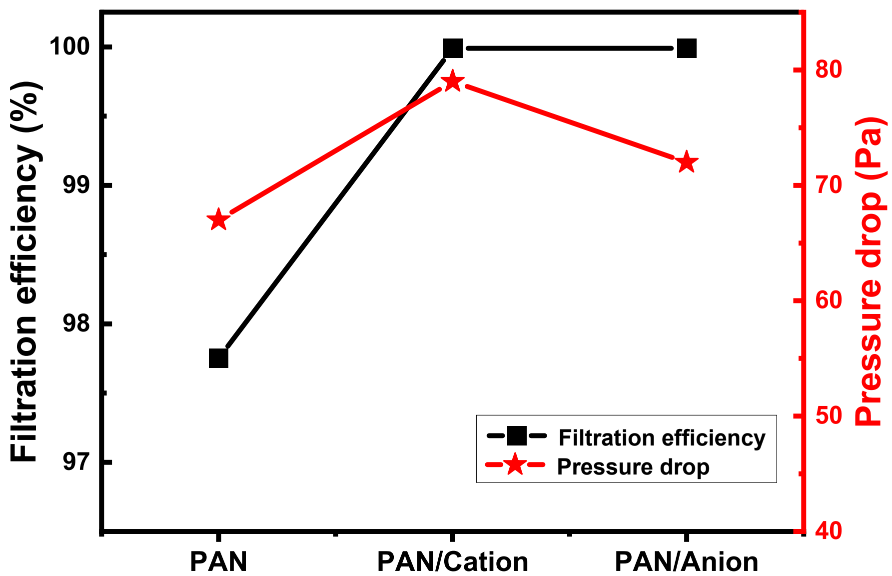


**Figure S16.** Filtarction efficient and presure drop of PAN, PAN/Cation (DTAB), and PAN/Anion (SDBS).

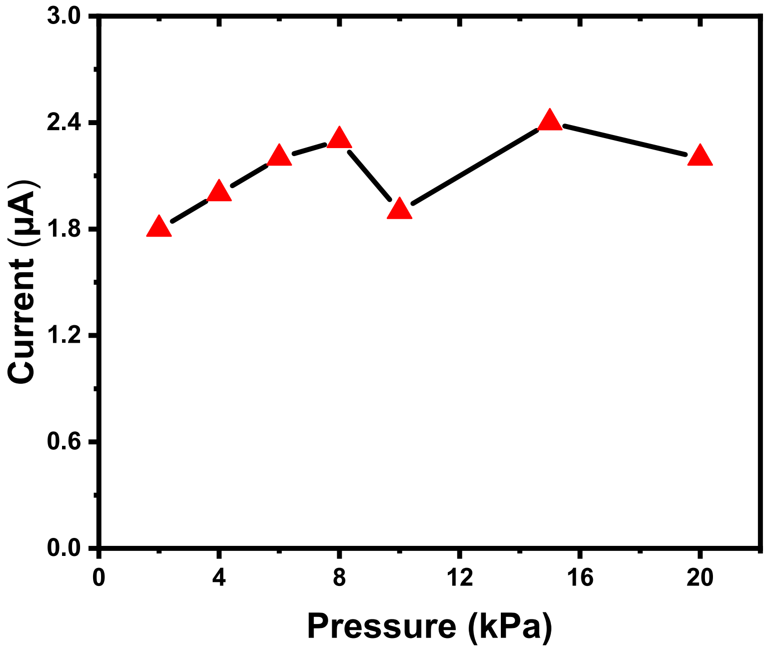


**Figure S17.** Current output of using different pressure to touching the device.

**Table S2** Air permeability of different type nanofiber.

| Type | PAN | PAN/Anion | PAN/Cation |
|---|---|---|---|
| Air permeability ($L/m^2/s$) | 66.27 | 25.99 | 16.79 |