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Supplementary Information

Highly Conductive PEDOT electrodes for harvesting dynamic energy through piezoelectric conversion

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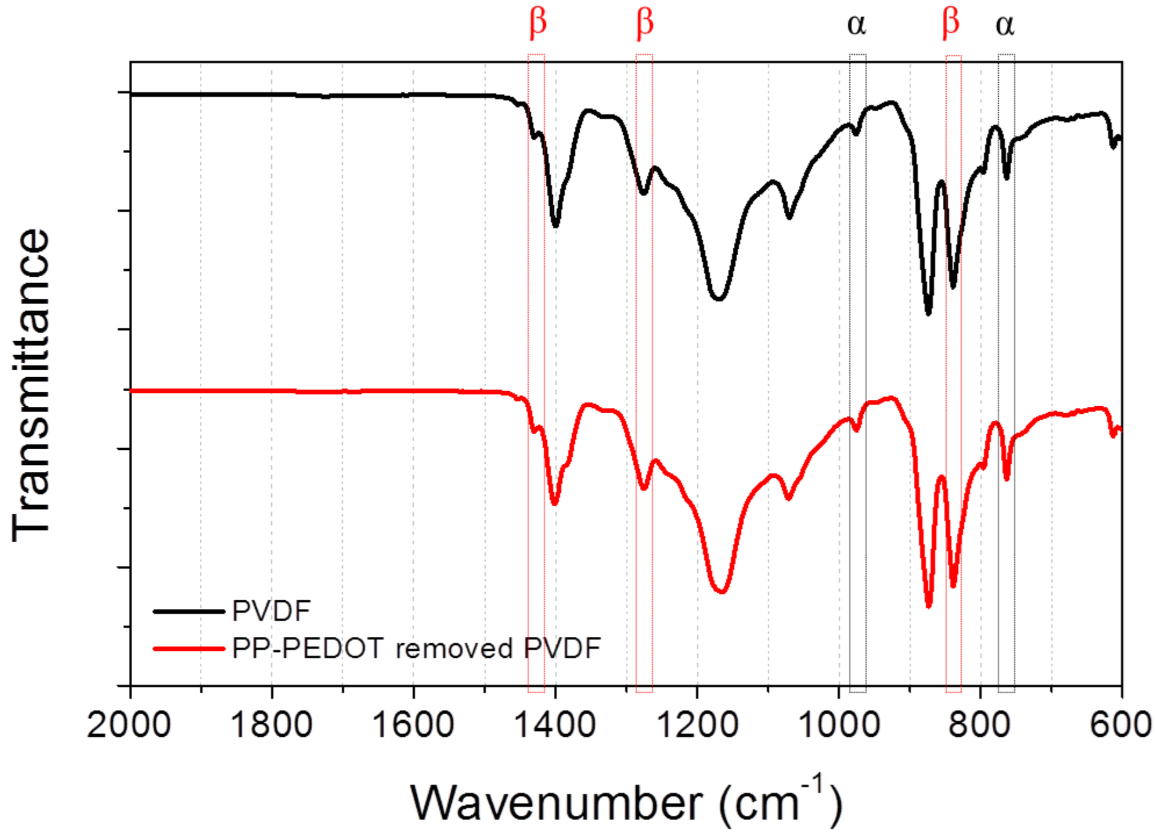

Figure S1. FT-IR spectra of the PVDF and after removing the PP-PEDOT electrode.

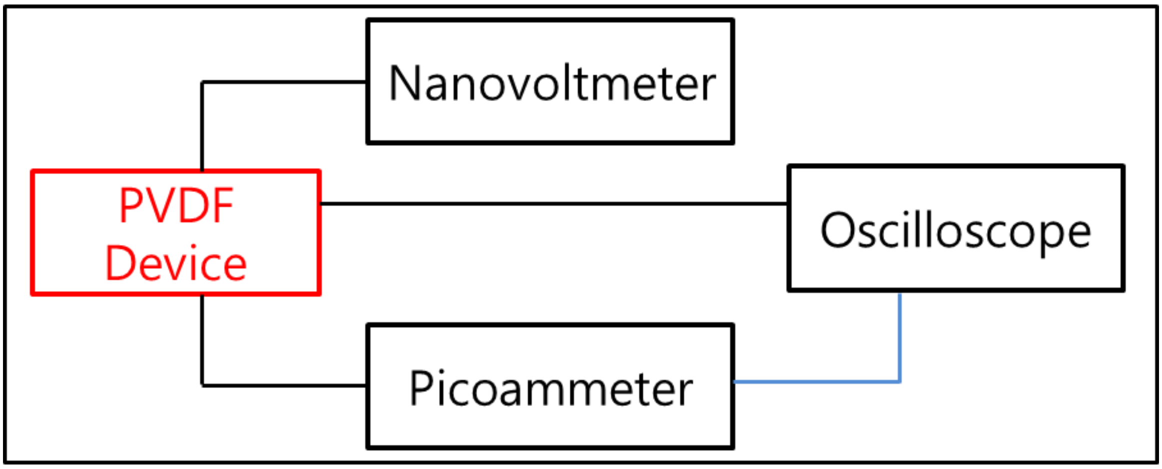

Figure S2. Schematic diagram of the measurement system, including digital conversion of the analogue current signal (blue line).

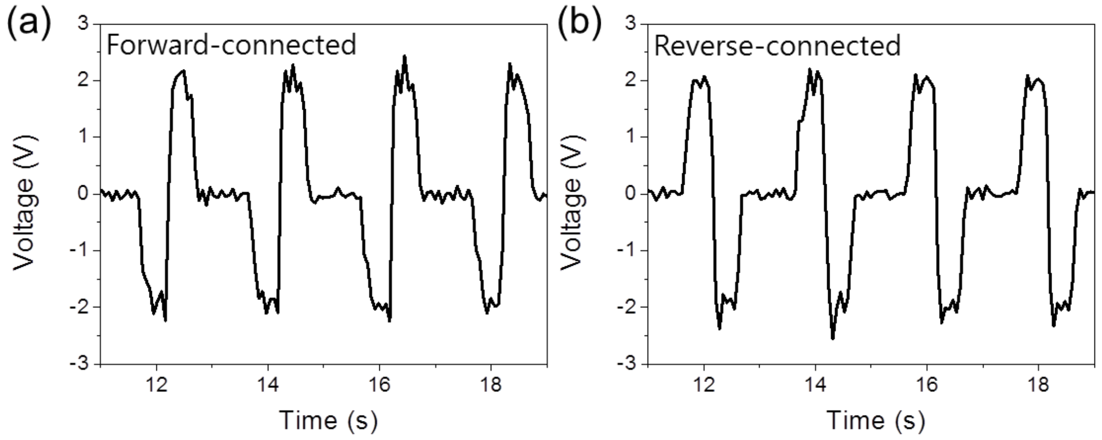

Figure S3. Output voltage measurements of the organic piezoelectric device (a) with forward and (b) reversed connection to the measurement system. Connections showed reversal in signal polarity as expected.

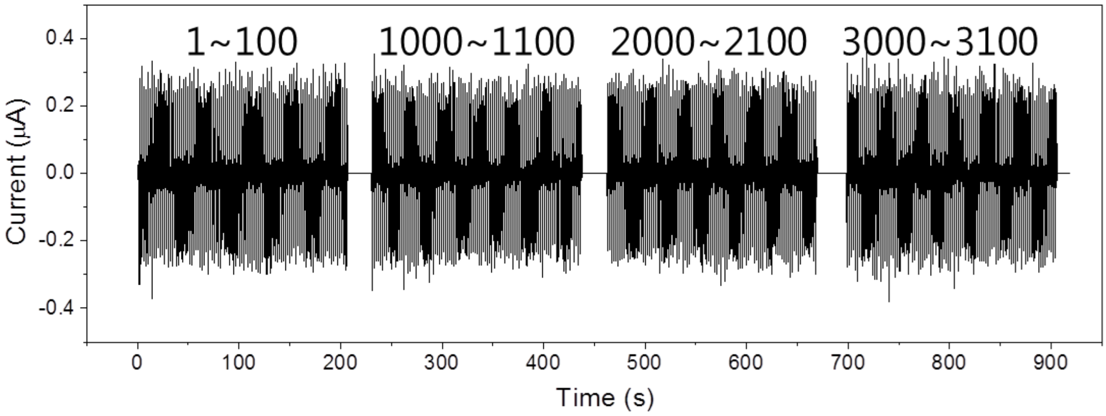

Figure S4. Measured output current of the PP-PEDOT electrode-substituted PVDF film from more than 3,000 mechanical stretching motions (450 mN) for a durability test.

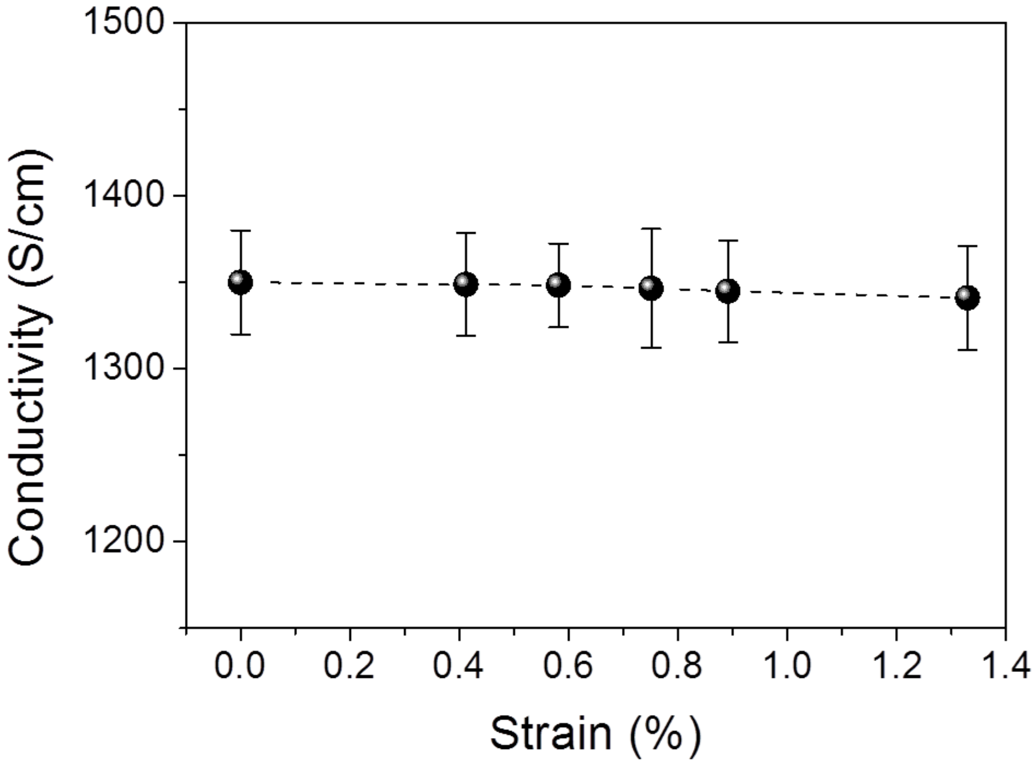

Figure S5. Electrical conductivity of the PP-PEDOT electrode coated on a PVDF film under different applied strains. (Error bars represent standard deviation (n=6))

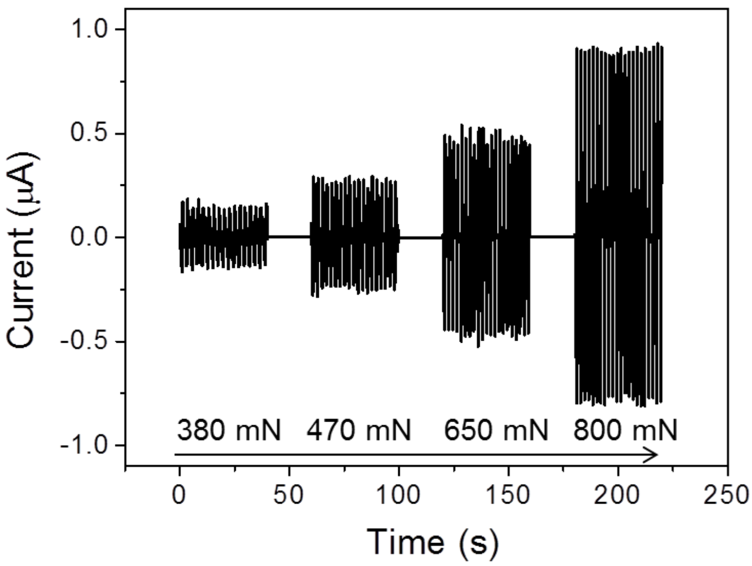

Figure S6. Measured output current of the PP-PEDOT electrode-substituted PVDF film with different amounts of mechanical stretching.

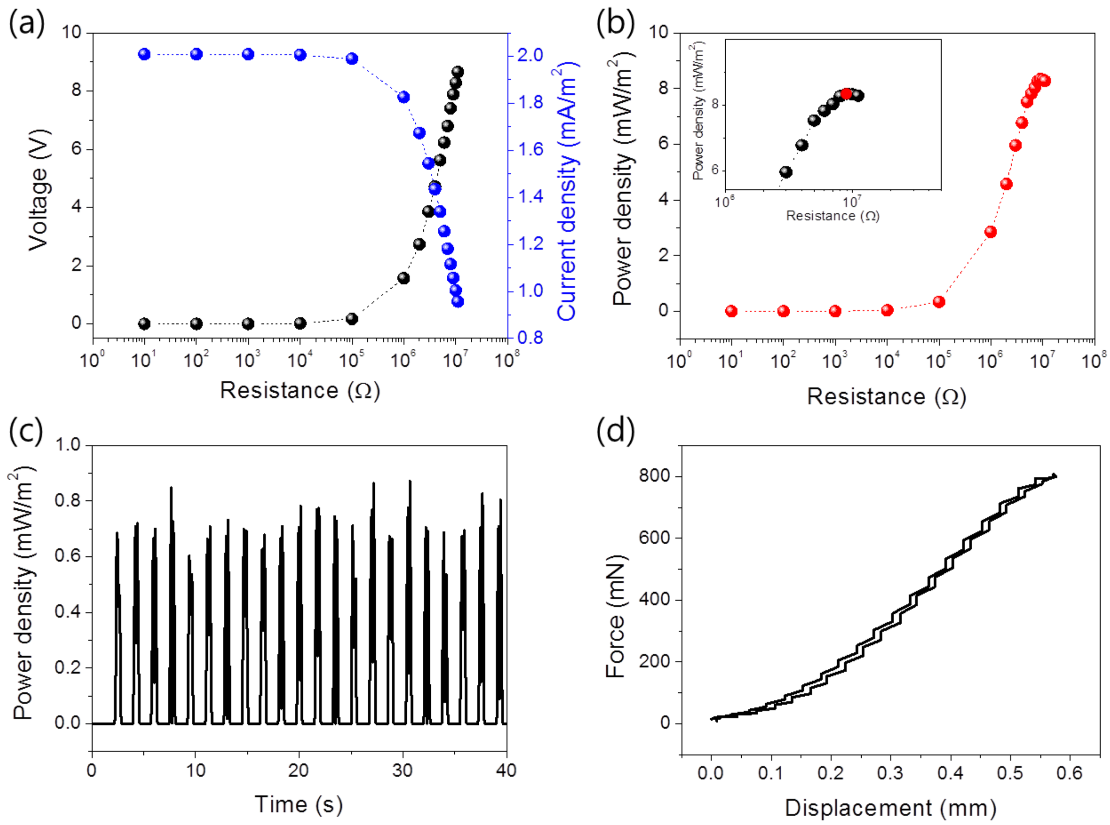

Figure S7. (a) Dependence of the output voltage and current density on external load resistance. (b) Dependence of the output power on external load resistance. Inset: enlarged image indicating maximum output power when R = 9 MΩ (red dot). (c) A plot of the power density (I^2R) of the piezoelectric device under 9 MΩ to obtain the value of E_{ele}. (d) A plot of the force versus displacement to calculate W_{mech}.

The estimation of the energy conversion efficiency

The maximum electrical energy generated by the stretching of the piezoelectric device in a cycle, can be estimated using the data of the output values with connection of external load. The maximum power output is reached at the resistance of 9 MΩ. Therefore, the maximum electric energy output (E_{ele}) [36] can be calculated by following equation (S1):

$$E_{ele} = \int I^2 R dt \quad \text{(S1)}$$

The value of E_{ele} was obtained through the integration of peaks in a cycle (Fig. S7(c)) as E_{ele} = 1.01×10^{-3} mJ.

Then, E_{ele} was divided by the calculated input mechanical energy of stretching (W_{mech}) to obtain the efficiency. The input mechanical energy was calculated by integrating force with respect to displacement as in equation (S2):

$$W_{mech} = \int_{x_i}^{x_f} F_x \, dx \quad \text{(S2)}$$

where F is force and x is displacement. W_{mech} was determined as 2.12×10^{-4} J from the data obtained by the UTM measurement instrument (Fig. S7(d)). When a piezoelectric device is stretched out, the reverse (return) movement to the pristine state is spontaneous. In order words, W_{mech} could be calculated from the stretching work only. Therefore, the practical energy conversion efficiency (η_{prac}) can be determined by following equation (S3), as all other loss factors such as friction, heat, and sound could be included into W_{mech} to calculate a practical efficiency:

$$\eta_{prac} = \frac{E_{elec}}{W_{mech}} \times 100\% \quad \text{(S3)}$$

Therefore, the practical energy conversion efficiency could be determined as 0.47%.

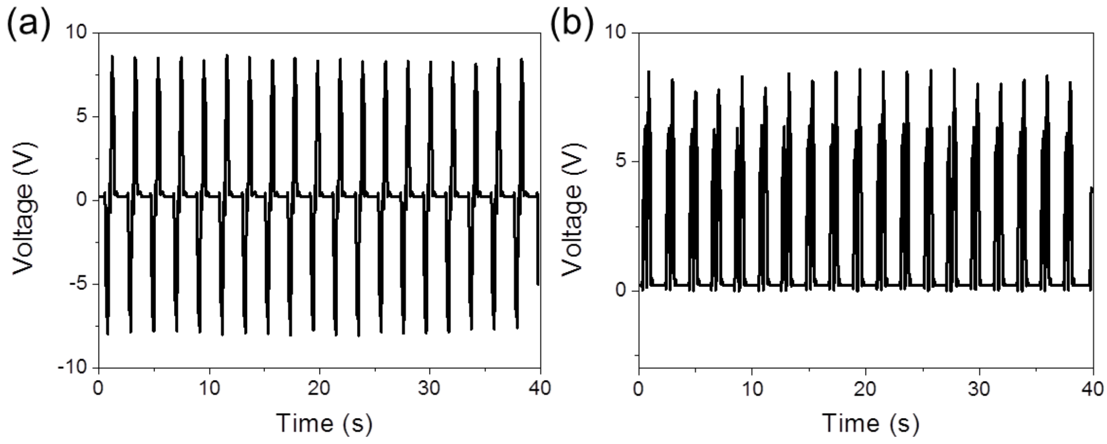

Figure S8. To convert the voltage outputs (applied 0.52% strain) to DC signals, a full wave rectifier bridge was used and output voltage signals of the piezoelectric device were measured (a) before and (b) after rectification.

Supplementary Video

Video S1. Yellow and white LEDs performance and confirmation of the output signal from human body movement.