Electrospun ion gel nanofibers for flexible triboelectric nanogenerator: Electrochemical effect on output power

Supporting Information

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Experimental

Preparation of the ion gel solution: poly(vinylidene fluoride-co-hexafluoropropylene), P(VDF-HFP) with Mn = 130 000 g mol-1 and Mw = 400 000 g mol-1 was purchased from Sigma-Aldrich. 1-Ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)amide, [EMIM][TFSI], was purchased from C-TRI Inc. The ion gel solution (10 wt% sample) was prepared by codissolving 100 mg of [EMIM][TFSI] and 1 g of P(VDF-HFP) in a co-solvent of 4 ml of acetone and 2 ml of dimethylformamide. The solution was stirred at room temperature for 1 hr.

Fabrication of the ion gel nanofibers: A conventional electrospinning setup was used to spin the ion gel nanofibers. The prepared ion gel solution was loaded into a syringe and the distance between the needle and the collector was set to 15 cm. The process was conducted at 10 kV with a 1 ml/hr feed rate. The nanofibers were collected on aluminum foil for 40 min at room temperature, and the area of the nanofibers was 16 cm × 16 cm and thickness was about 150 μm. The obtained samples were dried at 60 ^{o}C for 1 hr in air ambient. To fabricate the TENG, the spacer made of an insulating polymer film with double-side adhesives with a thickness of 0.03 mm was employed at the effective area (1 cm × 1 cm).

Characterization and Measurement: The morphologies of the ion gel nanofibers were characterized using a field emission scanning electron microscope (FE-SEM). The thickness of the ion gel nanofibers was measured using a Hyrox optical analyzer. The microstructure and bonding status of the ion gels were analyzed using XRD (PANalytical Inc., model no. X'pert-pro) and FTIR (Thermo Scientific Inc., model no. Nicolet iS 10). A pushing tester (Labworks Inc., model no. ET-126-4) was used to create a vertical compressive strain in the TENG. A Tektronix DPO 3052 Digital Phosphor Oscilloscope and a low-noise current preamplifier (model no. SR570, Stanford Research System, Inc.) were used for the electrical measurements.

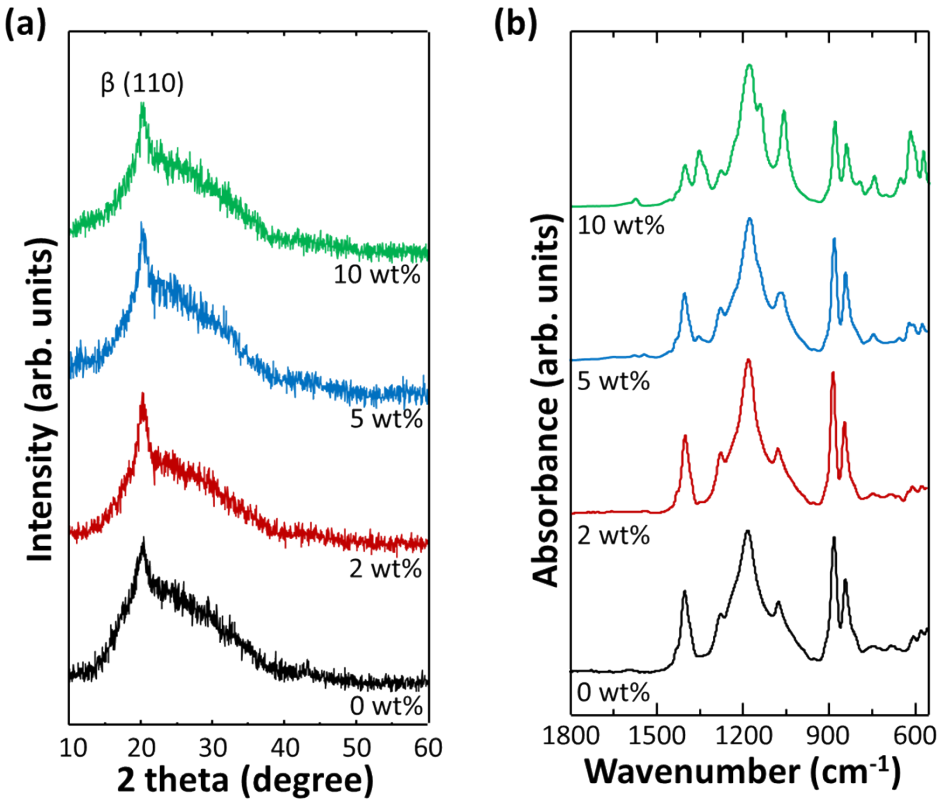

Fig. S1. (a) XRD patterns of the ion gel nanofibers as a function of doping concentrations. The characteristic peak with 2θ at 20.5° is assigned to the total diffraction in the (110) and (200) planes. The peak at 18.6° corresponds to the reflection of the (020) plane of the α-phase. (b) The FTIR spectra of ion gel nanofibers with different ionic liquid doping concentrations. Vibrational bands at 1276, 841, and 1232 cm^{-1} are attributed to the β-phase and γ-phase of P(VDF-HFP). Newly appeared peaks at 1152, 796, and 613 cm^{-1} are related to the α-phase of P(VDF-HFP). Several peaks in the region between 1348, 1132, 500 and 750 cm^{-1} are assigned to [EMIM][TFSI] related peaks.

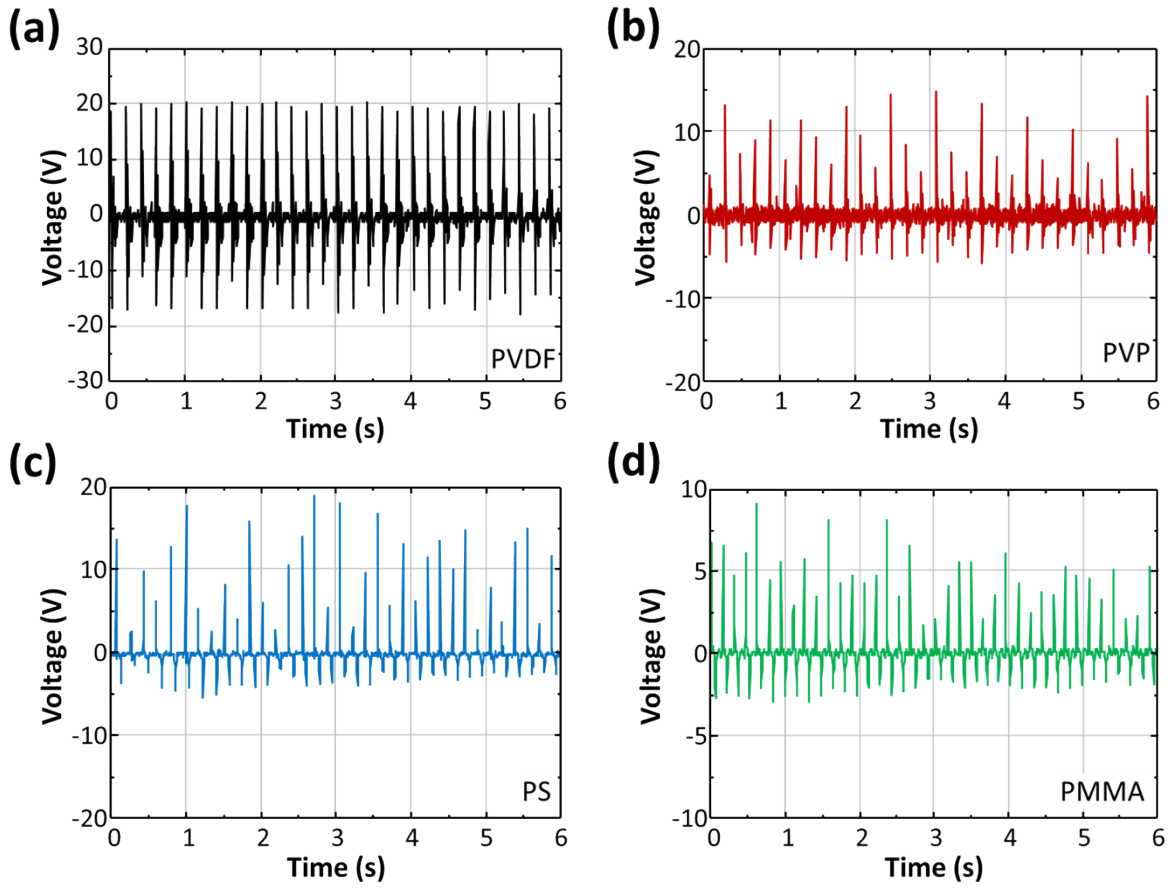

Fig. S2. Output voltage characteristics of TENGs with various polymer nanofibers as triboelectric materials. All polymer nanofibers were fabricated using an electrospinning process.

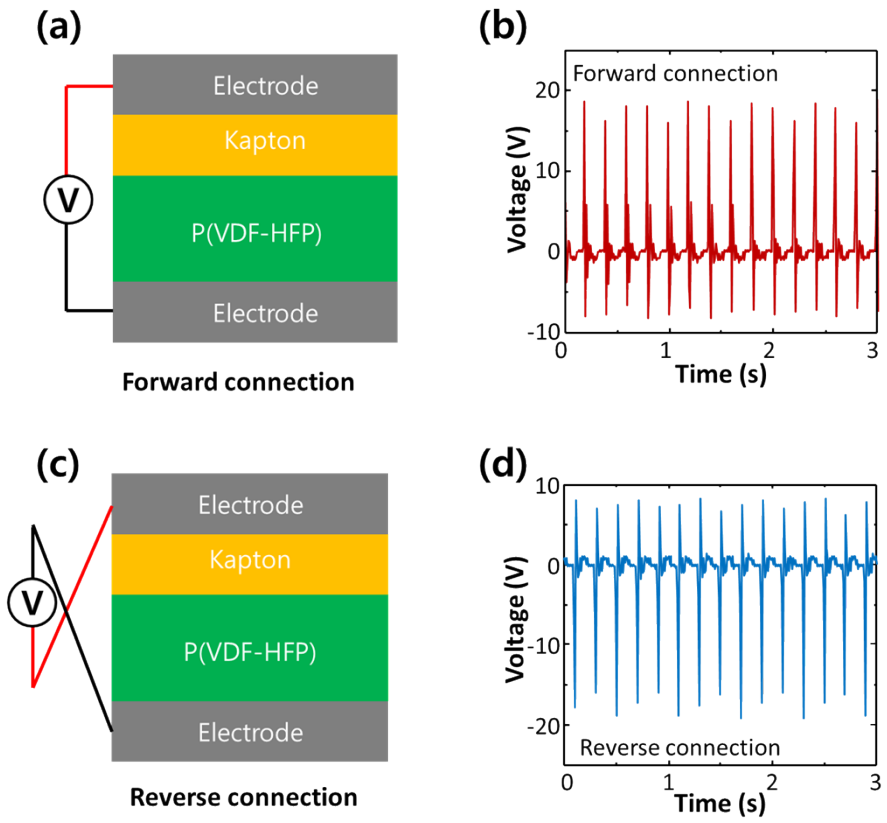

Fig. S3. Output voltage signal of TENG under the (a-b) forward and (c-d) reverse connections.

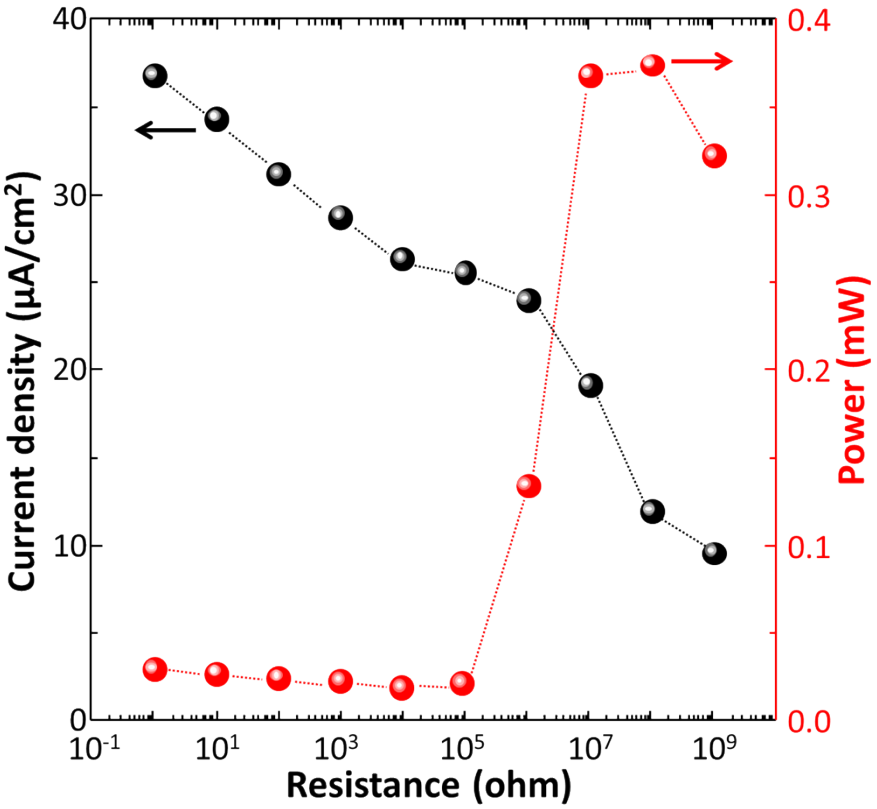

Fig. S4. Current and power of the TENG with ion gel nanofiber mat as a function of load resistants.

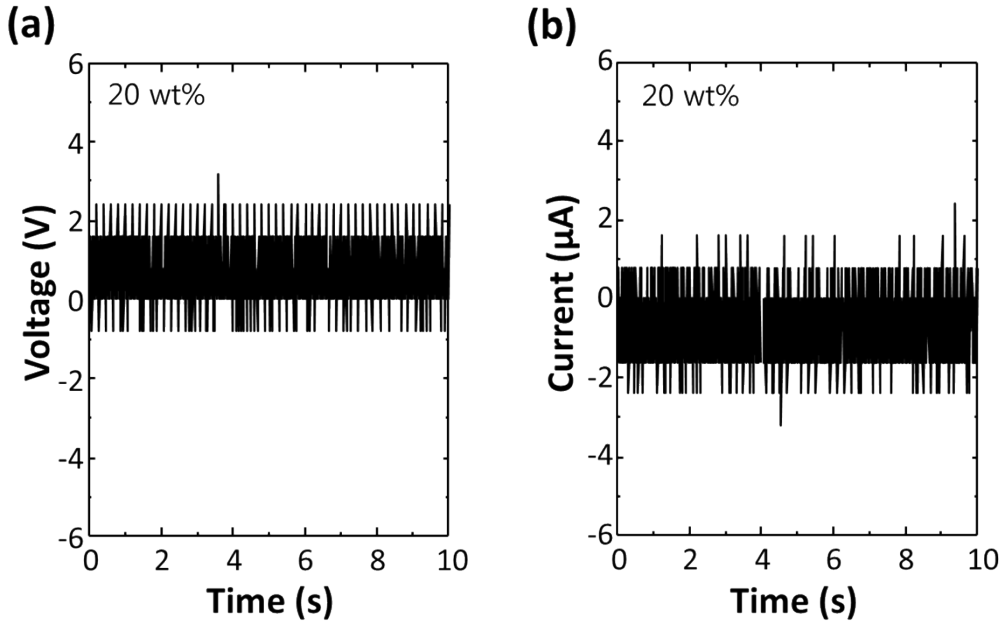

Fig. S5. (a-b) Output voltage and current characteristics of TENG with 20 wt% ion gel nanofibers.