Supporting Information

Standalone 3-D Piezoelectric Polymer-Ceramic Foam for Efficient Energy Harvesting

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1. Synthesis of BFO Nanoparticles

A dilute nitric acid solution was prepared, and then the precursors $Bi(NO_3)_35H_2O$ and $Fe(NO_3)_39H_2O$ were dissolved in it simultaneously. These two solutions were mixed until a clear solution was formed with no sediments. Further, 8M KOH was prepared and poured drop by drop into the aforementioned solution till a brown precipitate was produced. After stirring for 30 minutes, the solution was transferred to a stainless-steel autoclave with a Teflon lined container. The autoclave was heated in an oven at 180 °C for 12 hours. The sediment was filtered when the solution had naturally cooled to room temperature by rinsing it many times with distilled water until the pH reached 7. It was finally dried in an oven at 80 °C, yielding brown-colored nanopowders.

2. Synthesis of KNN Nanoparticles

KNN was prepared using a hydrothermal reaction involving KOH, sodium hydroxide (NaOH), and niobium pentoxide (Nb_2O_5). A 3:1 molarity ratio of KOH and NaOH were dissolved in distilled water to form a 60 ml solution to form a final concentration of 6 M. The correct amount of Nb_2O_5 was then dispersed in the aforesaid solution and agitated for nearly an hour. This solution was then hydrothermally treated for 24 hours at 180 °C. The precipitate was rinsed with DI water numerous times until the pH reached 7. It was then dried for 12 hours at 85 °C.

3. Characterizations

X-ray diffraction (XRD, Shimadzu, XRD-7000L, Japan) was used to analyse the crystalline phases of the BFO, KNN NPs, and the fabricated foams. The electroactive phase and functional groups present in the pristine and composite foams were analysed using Fourier Transform Infrared Spectroscopy (FTIR) (Continuum Nicolet 6700, M/s Thermo Electron Corporation, USA). Field Emission Scanning Electron Microscopy (FE-SEM, Thermosceintific Apreo S at an accelerating voltage of 20 kV) was used to study the surface morphology and elemental

composition of the foams. Thermo Gravimetric Analysis (TGA, Q50, TA INSTRUMENTS, USA) and Differential Scanning Calorimetry (DSC, Q20, TA INSTRUMENTS, USA) techniques were used to investigate the thermal properties of the manufactured foams. Further, the electrical response of the produced foams was tested using an electrometer (Keithley 6514) by applying mechanical stress using a linear motor (Linmot, HF01-37).

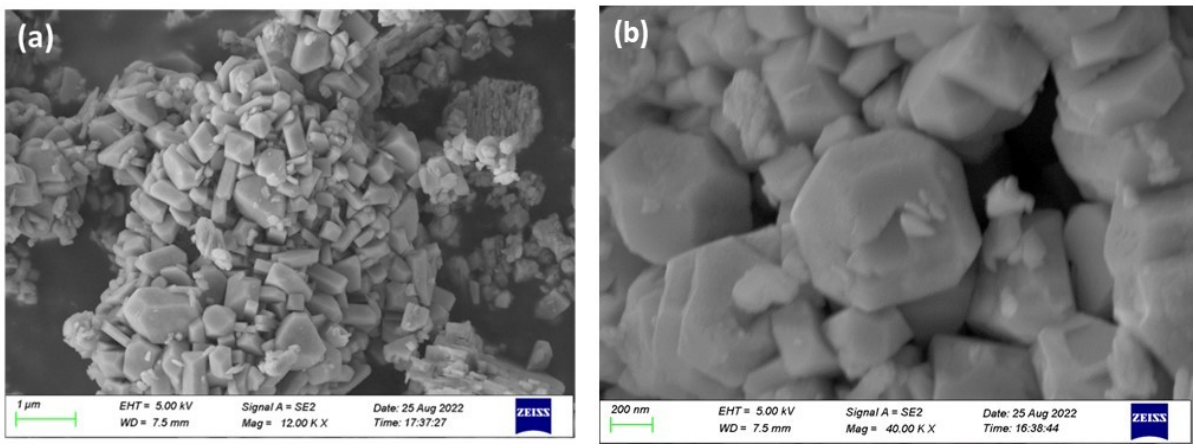

Figure S1. FE-SEM image of (a) BFO and (b) KNN nanoparticles.

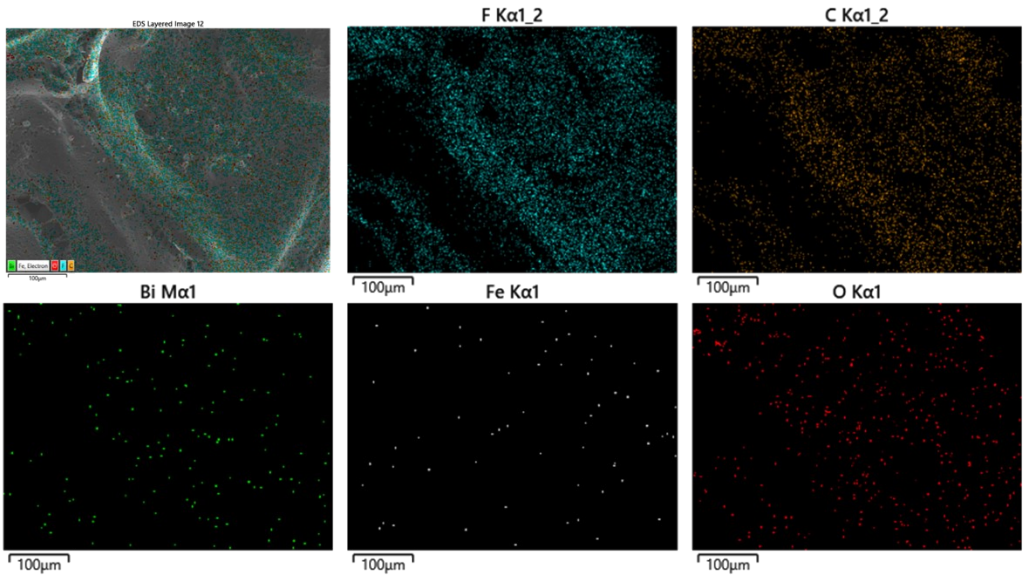

Figure S2. EDS mapping images of the PVDF-2%-BFO foam.

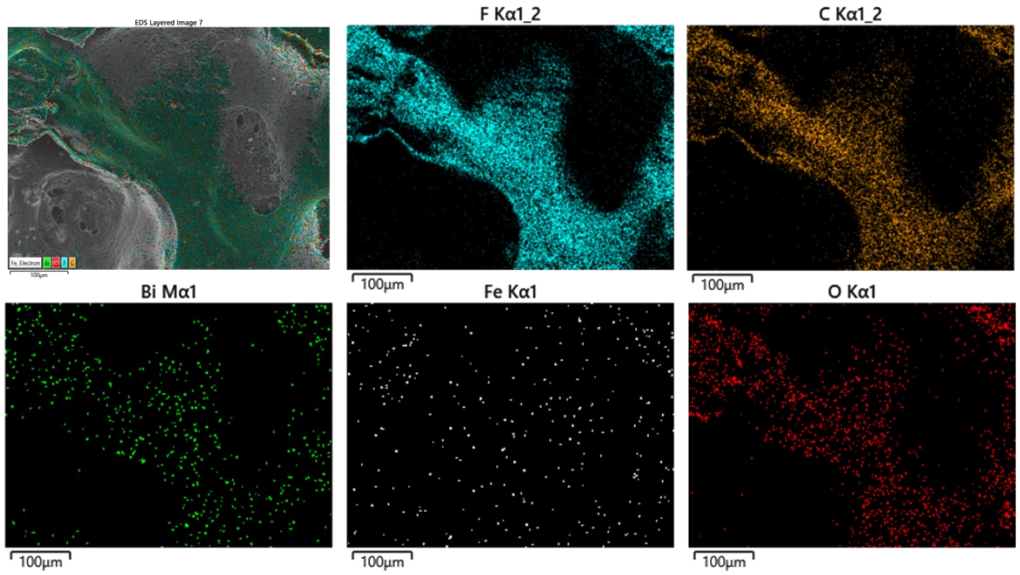

Figure S3. EDS mapping images of the PVDF-4%-BFO foam.

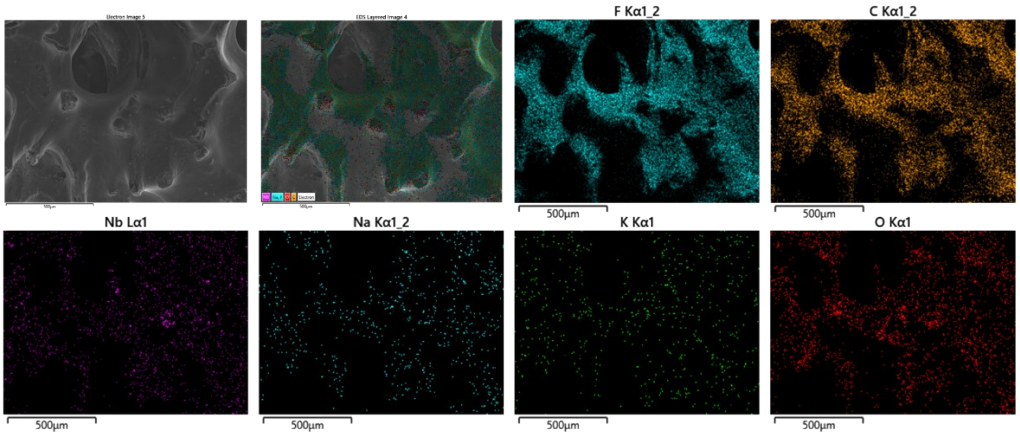

Figure S4. EDS mapping images of the PVDF-2%-KNN foam.

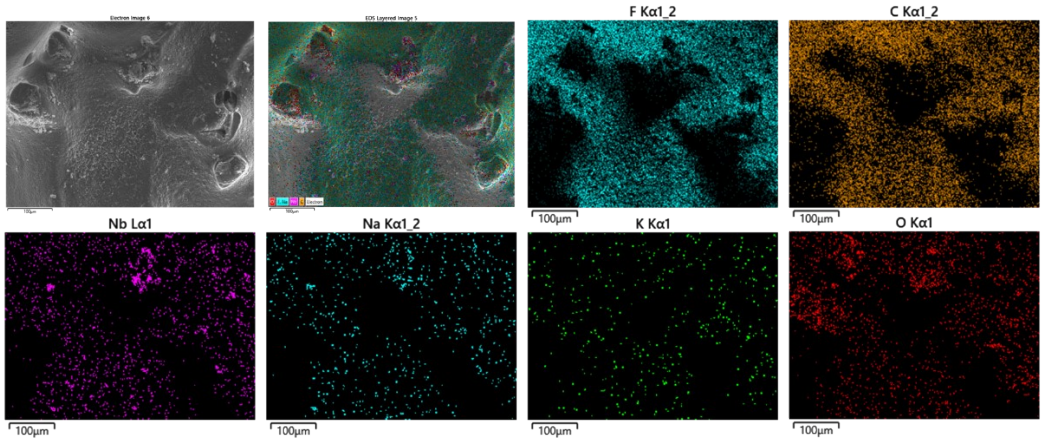

Figure S5. EDS mapping images of the PVDF-4%-KNN foam.

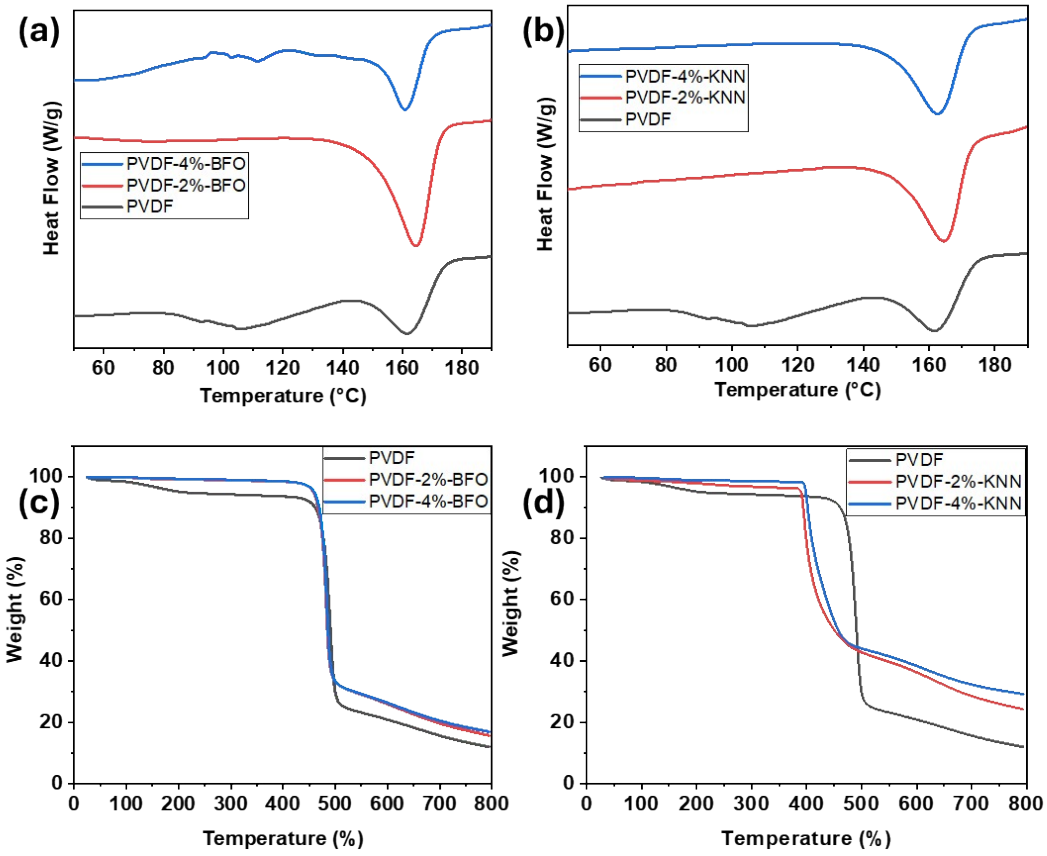

Figure S6. DSC spectra of the (a) PVDF-BFO, and (b) PVDF-KNN foams. TGA curves of the foams (c) PVDF-BFO and (d) PVDF-KNN.

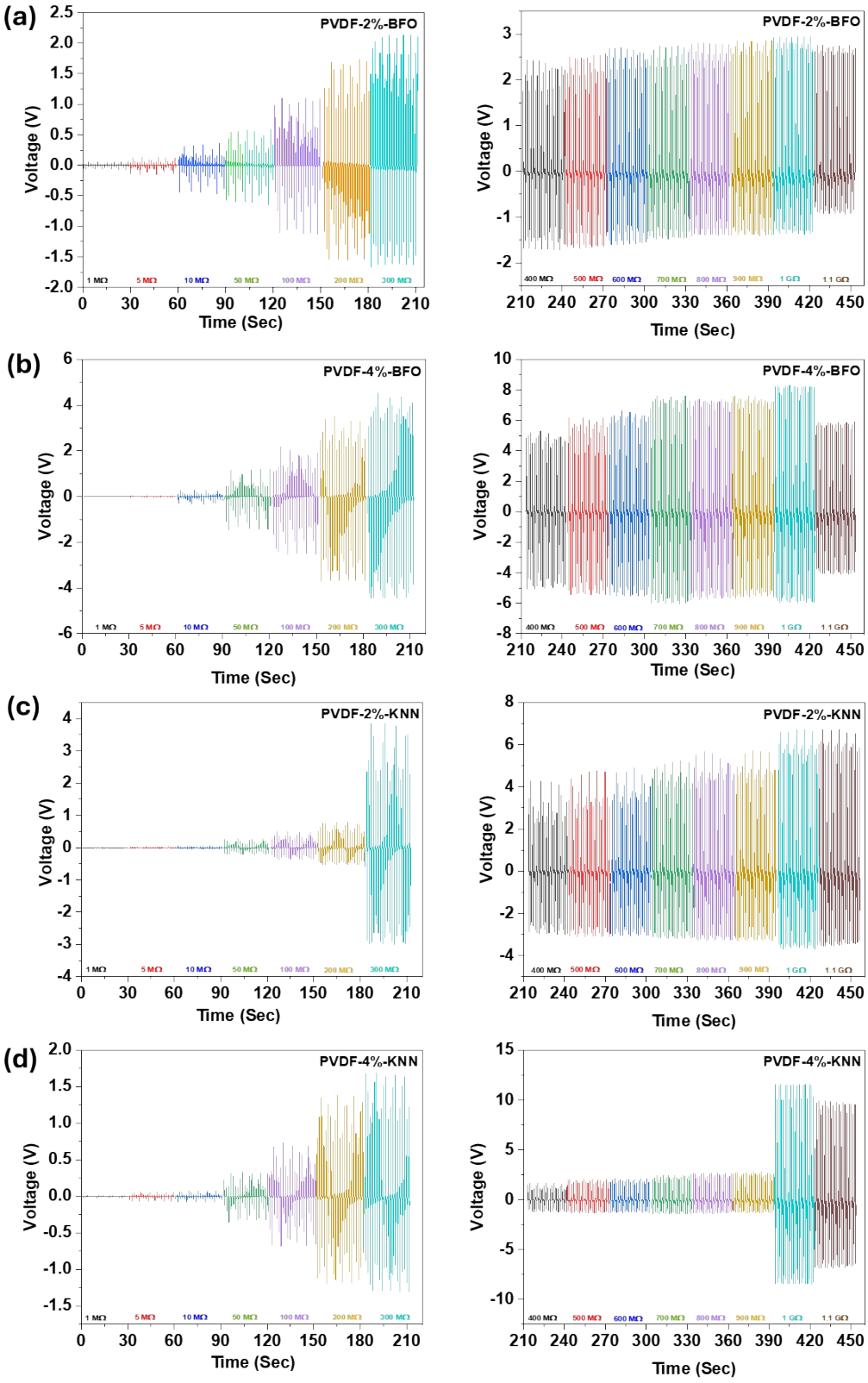

Figure S7. Open circuit voltage of (a) PVDF-2%-BFO, (b) PVDF-4%-BFO, (c) PVDF-2%-KNN and (d) PVDF-4%-KNN foam-based PENG devices at various load resistances.

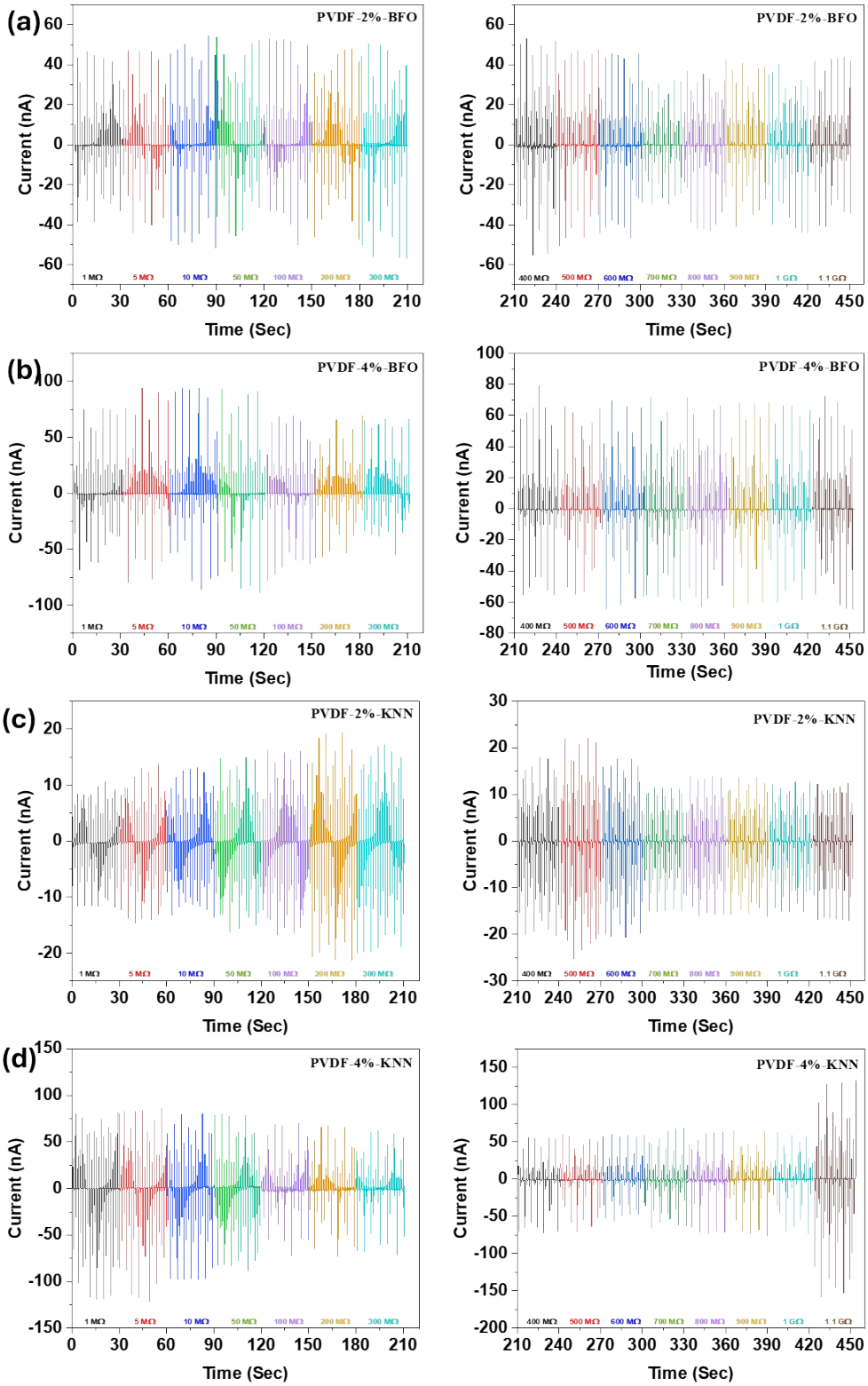

Figure S8. Output current generated by the (a) PVDF-2%-BFO, (b) PVDF-4%-BFO, (c) PVDF-2%-KNN and (d) PVDF-4%-KNN foam-based PENG devices at various load resistances.

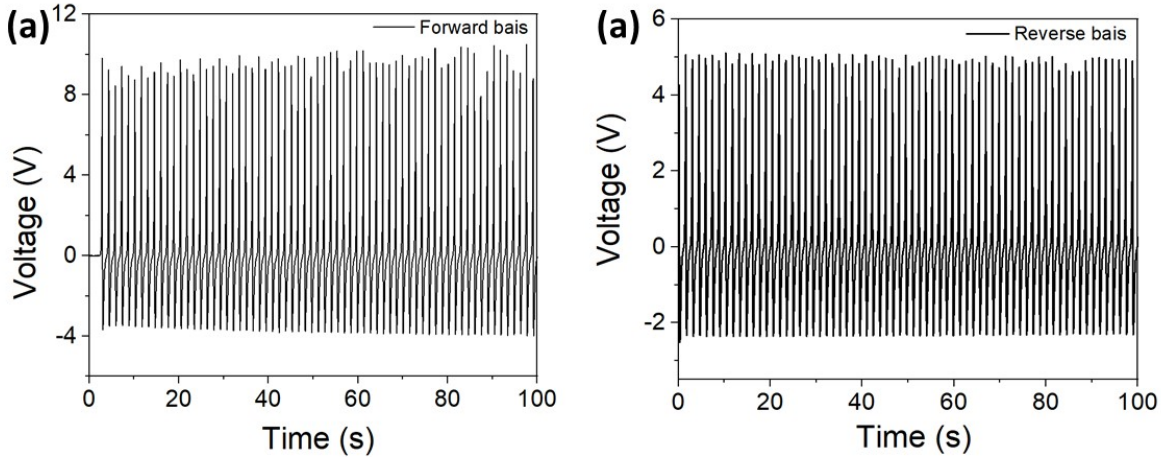

Figure S9. Forward and reverse bias characteristics of PVDF-4%-KNN foam-based PENG device.

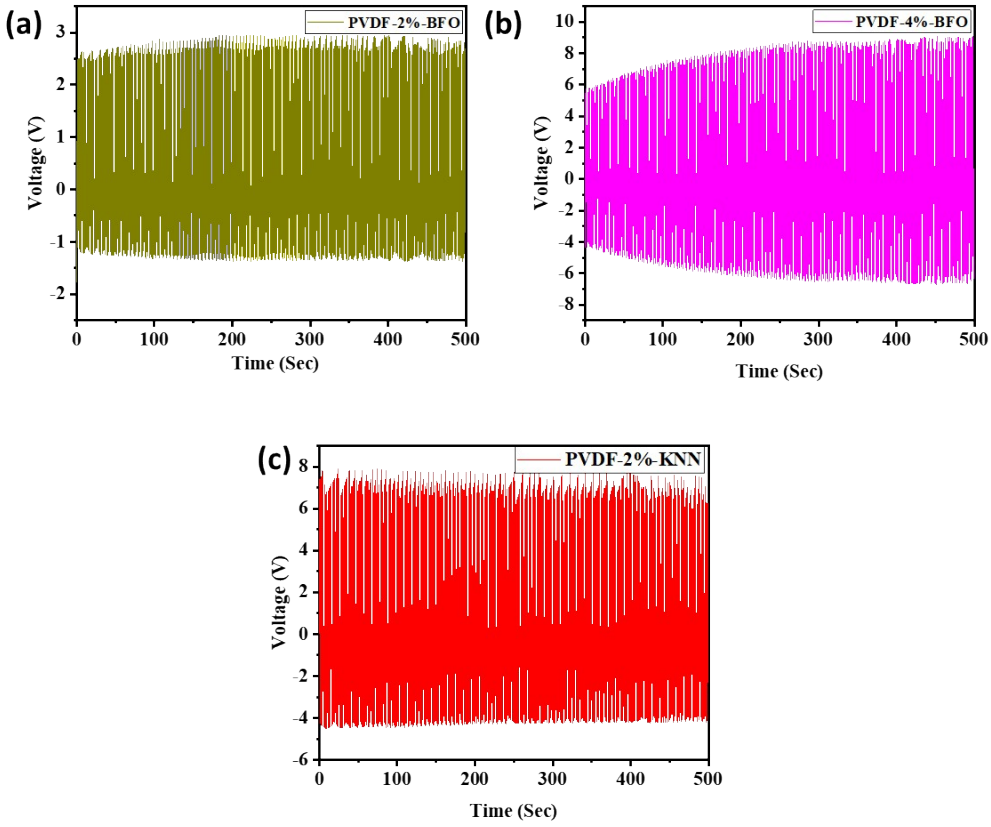

Figure S10. Stability tests of (a) PVDF-2%-BFO, (b) PVDF-4%-BFO, and (c) PVDF-2%-KNN foam-based PENG devices for 500s.

Figure S11. Digital images illustrating the measurement of applied forces using a pressure sensor during different actuation modes.