Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Supporting Information

Electrospun PVDF-KNN Nanofiber based Lead-free Piezoelectric Nanogenerator for Mechanical Energy Scavenging and Self-powered Force Sensing Applications

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Solid State Synthesis of KNN nanoparticles

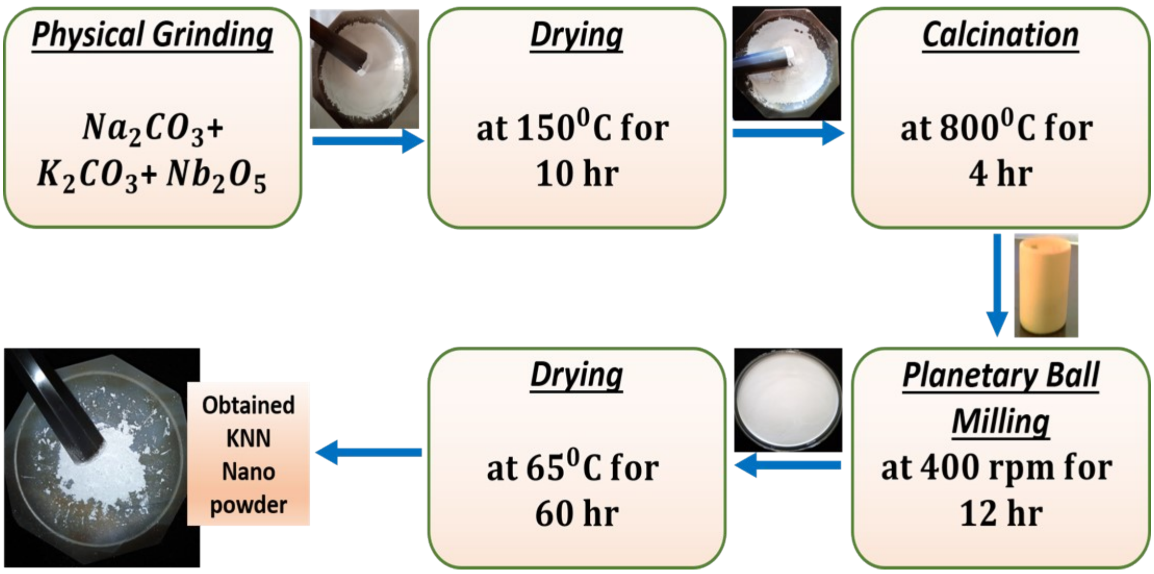

Figure S1: Schematic of solid-state synthesis of KNN nanoparticle

FTIR of nKNN nanoparticles

FTIR analysis was done for the confirmation of bonds. The peak at 669 cm^{-1} arises from the oxygen octahedra ensures the formation of perovskite structure

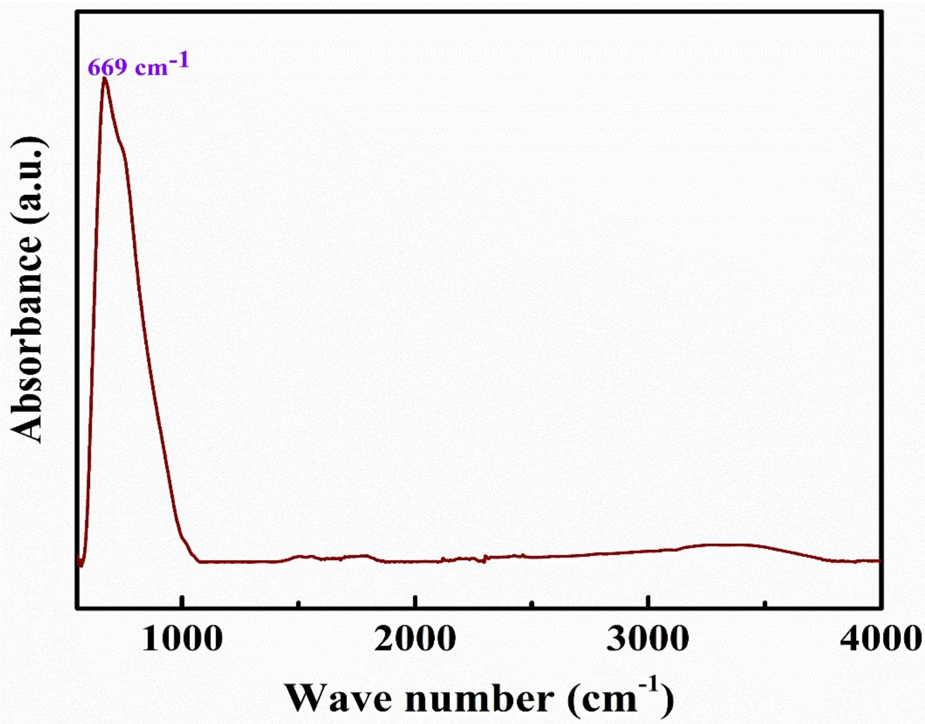

Figure S2: FTIR spectra of nKNN nanoparticles

SEM image of mKNN and FPVDF- mKNN

Irregular edges with randomly sized polygon in mKNN is evident from SEM image of the mKNN nanoparticles (Figure S3 (a)). Diameter distribution of FPVDF with 10 wt% mKNN falls in the range of 1000 nm (Figure S3 (b)).

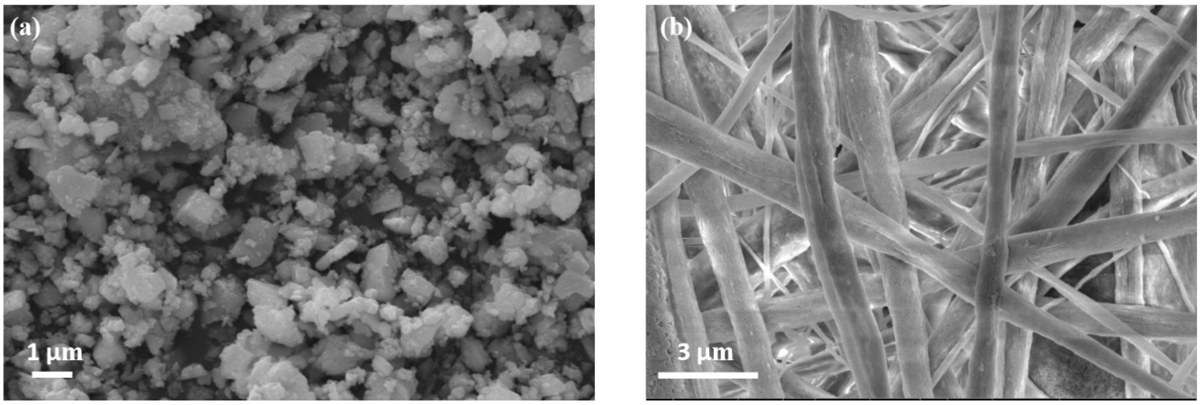

Figure S3: (a) SEM image of mKNN and (b) SEM image of FPVDF-mKNN

SEM image of pristine FPVDF

For analysing the effect of incorporation of KNN nanoparticles, SEM image of pristine PVDF nanofibers were also taken (Figure S4). Comparing to FPVDF-10 nKNN, diameter is slightly less (400- 600 nm) for the bare one.

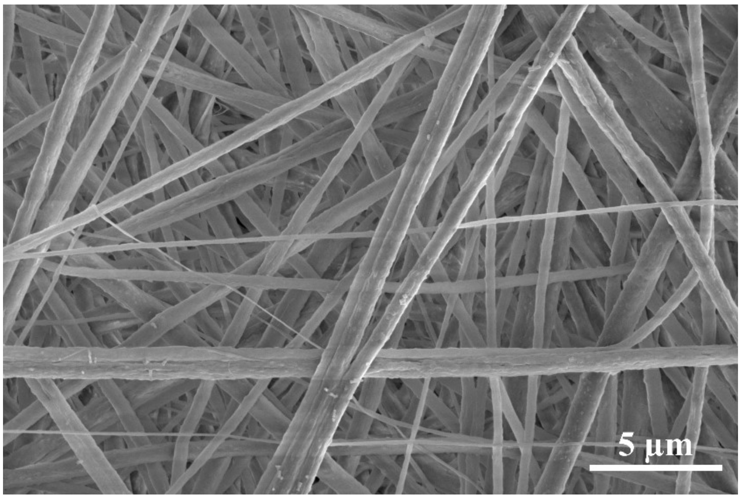

Figure S4: SEM image of pristine PVDF nanofiber

Stress- strain graph and SEM image of FPVDF- 10 nKNN after continuous 10,000 press- release cycles

Under a force of 10 N, our current PENG device provides a significant open-circuit voltage of 25 V with a short-circuit density of 5 mA/m^2. Only a little force was applied to the device when it is being used for tactile sensing (0.125 kPa- 250 kPa). Additionally, a stress of 0.5 tons (or 12 MPa) and a temperature of 150 ^{0}C in transverse direction were applied throughout the device fabrication process. Even after applying a stress of 12 MPa, structural integrity of the fibers without any degradation is still visible from the SEM image (Figure 3 (a)). So, even after continuous 10,000 press- release cycles with a force of 10 N, change in morphology of the fibers are not observed. We had applied a stress along longitudinal direction also. The stress- strain graph shows the fibers could withstand a longitudinal stress around 0.8 MPa and might be due to improper orientation of fibers.

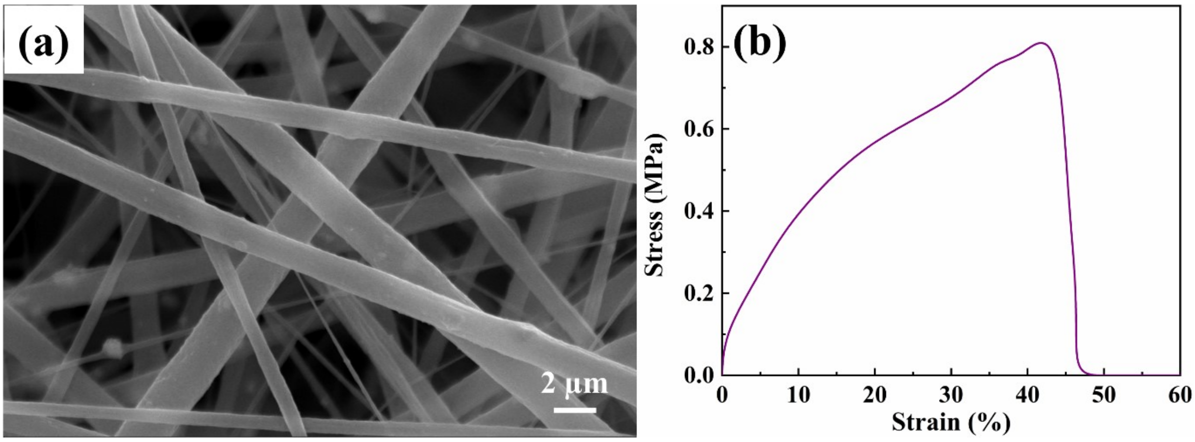

Figure S5: (a) SEM image of FPVDF- 10 nKNN after continuous 10,000 press- release cycles and (b) stress- strain graph of FPVDF-10 nKNN applied stress along the longitudinal direction

RMS power from the device FPVDF- 10 nKNN based PENG

RMS power density of the device across various loads from 5 kΩ to 1 GΩ were calculated by taking root of mean of squares of voltage values for a single AC signal across each load. A maximum RMS power density of 0.23 mW/m^2 was achieved at 10 MΩ which is less compared to the actual power density.

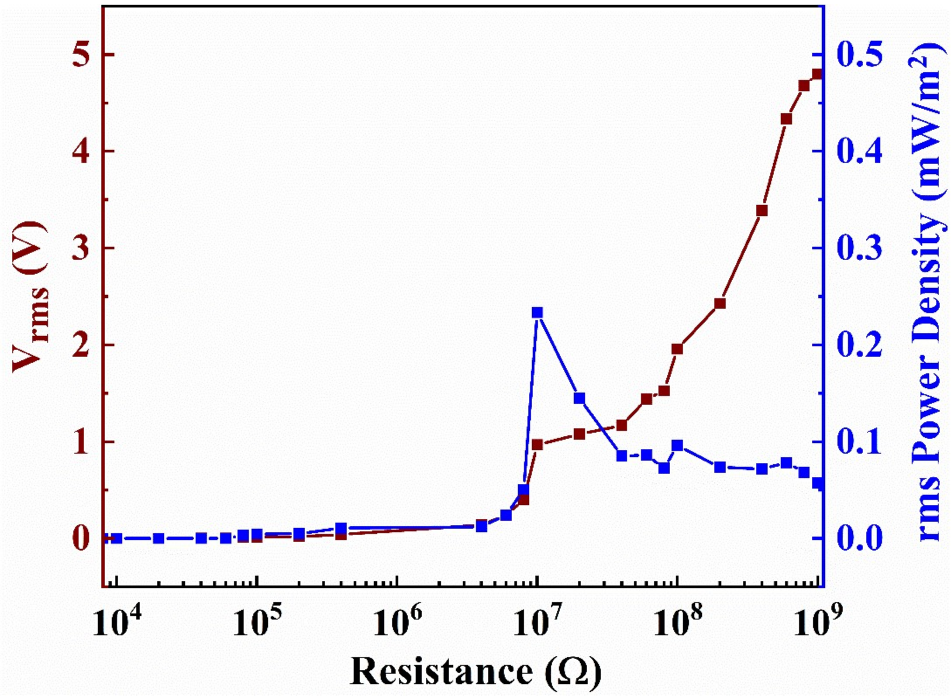

Figure S6: Load characteristics of FPVDF-10 nKNN with rms voltage and power density

Polarity test for the PENG with FPVDF-10nKNN

For confirming the fact that the origin of the output signal is purely from piezoelectric property of the material according to the piezoelectric principle, measurement was done by reversing the connection. The polarity got reversed keeping magnitude of open- circuit voltage to 25 V (figure S7).

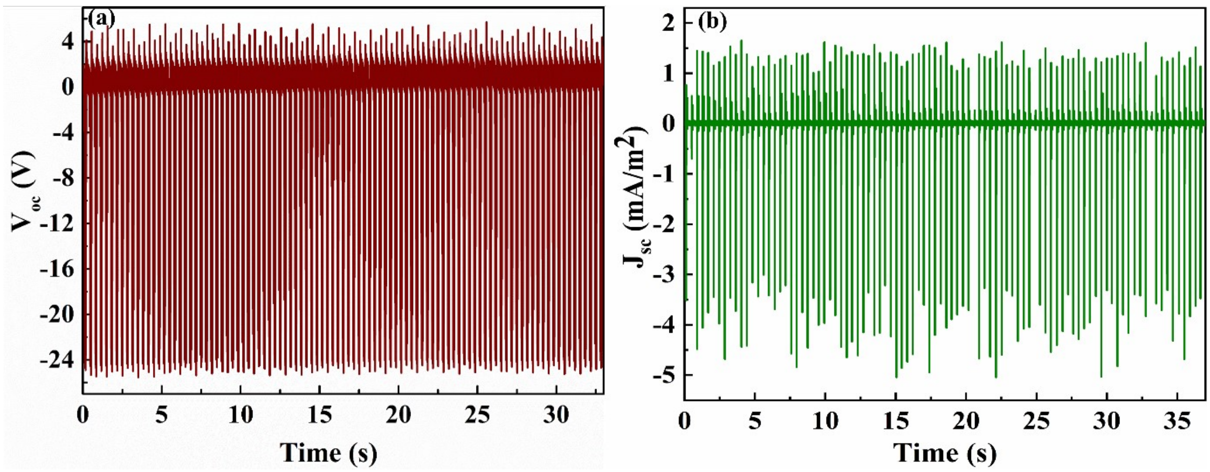

Figure S7: (a) Open-circuit voltage and (b) short- circuit current density for the PENG with FPVDF-10nKNN while reversing the connection.

Supplementary video 1: powering digital thermometer

Supplementary video 2: powering calculator