Supporting Information

Electrospun Hybrid Nanofibers of Poly(vinylidene fluoride) and Functionalized Graphene Oxide as Piezoelectric Energy Harvester

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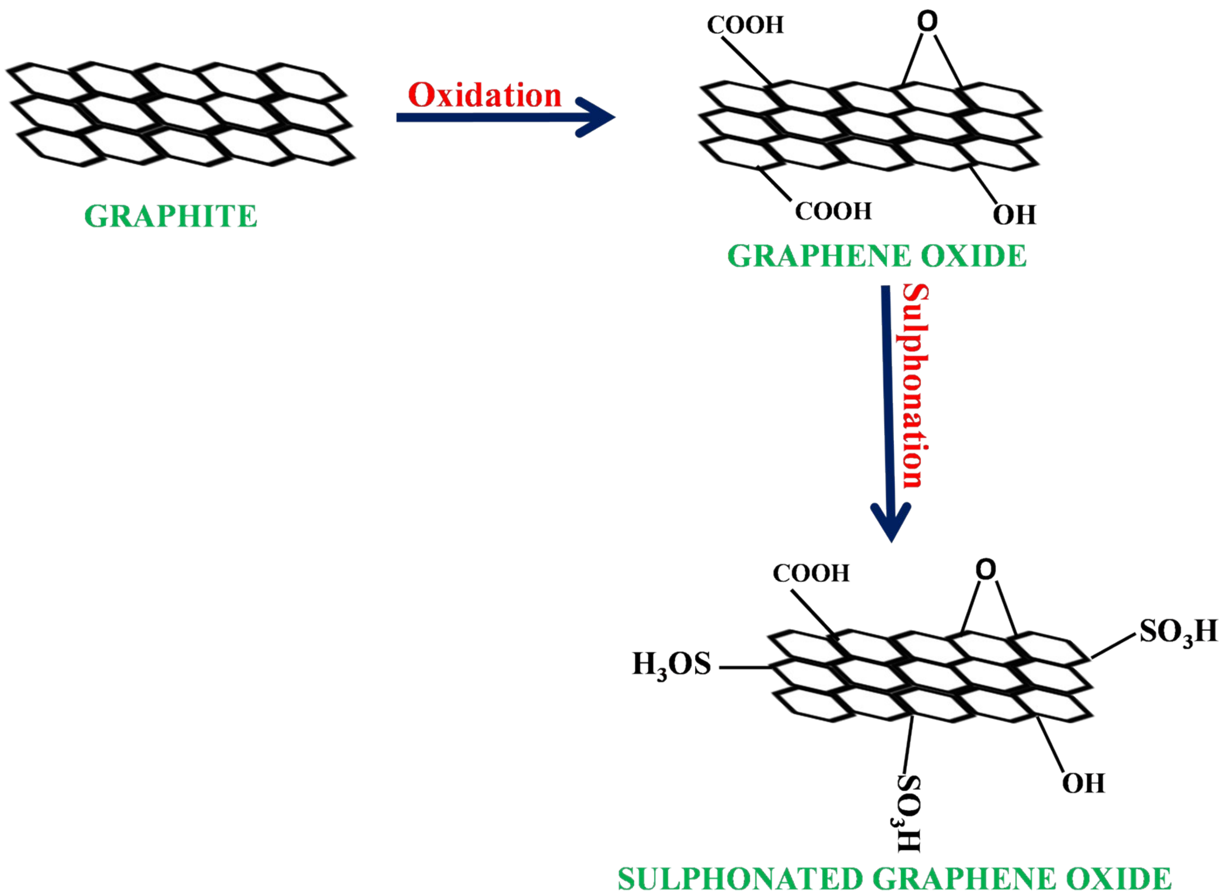


Figure S1: Schematic representation of the preparation of Graphene Oxide (GO) and Sulphonated Graphene Oxide (GS)

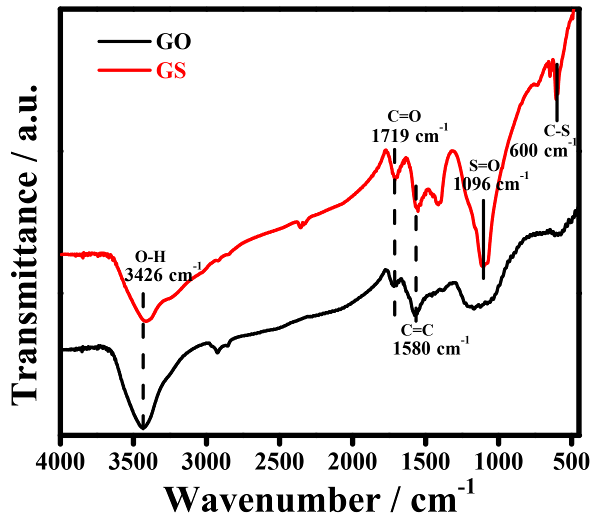


Figure S2: FTIR spectra for graphene oxide and its subsequent functionalized graphene oxide.

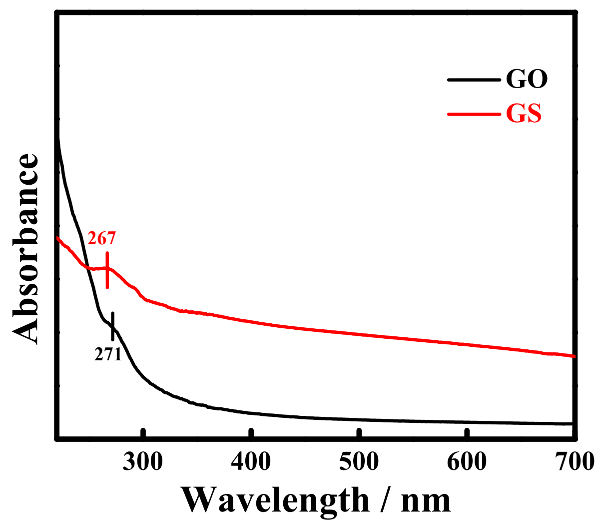


Figure S3: UV- visible spectra for graphene oxide and functionalized graphene oxide

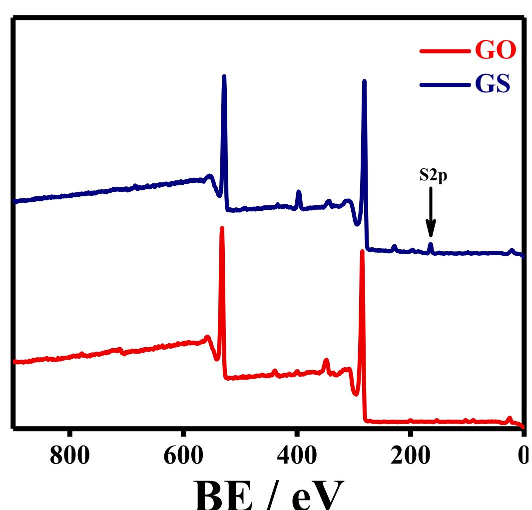


Figure S4: XPS spectra for graphene oxide and functionalized graphene oxide

Optimization for Electrospinning

Electrospinning parameters like voltage, flow rate, concentration and solvent ratio were optimized to achieve a better quality fibre for the energy harvesting applications.

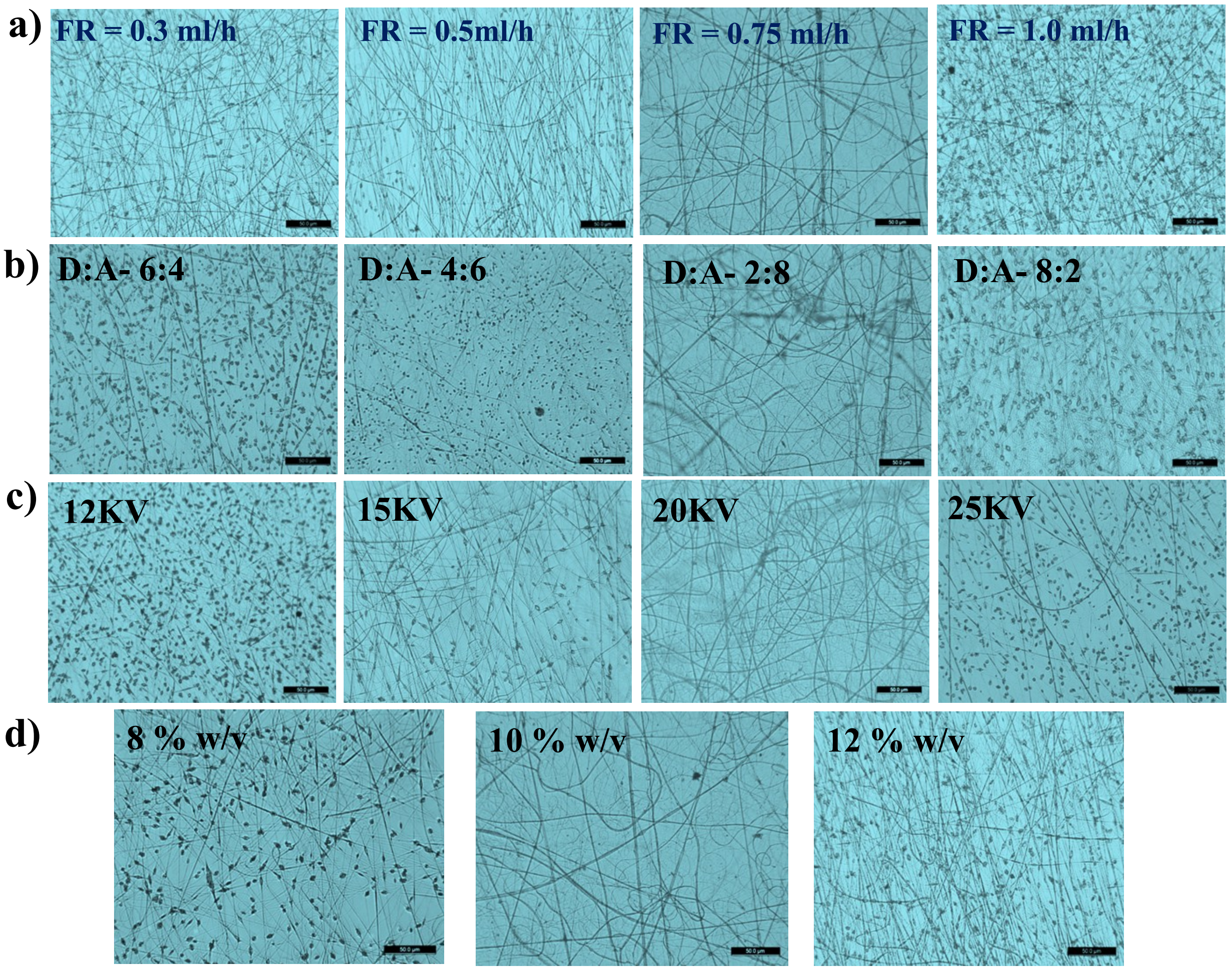


Figure S5. Polarized Optical Microscopy (POM) images showing the fibers obtained from electrospinning at different **a)** flow rate **b)** solvent ratio **c)** voltage and **d)** solution concentration.

Electrospinning is a well-known process for the fibre preparation in variable sizes. Certain factors like voltage, flow rate, solution concentration and solvent ratio play important role for the better quality fiber. From the following optimizations, conditions to prepare better quality fibres were chosen and implemented.

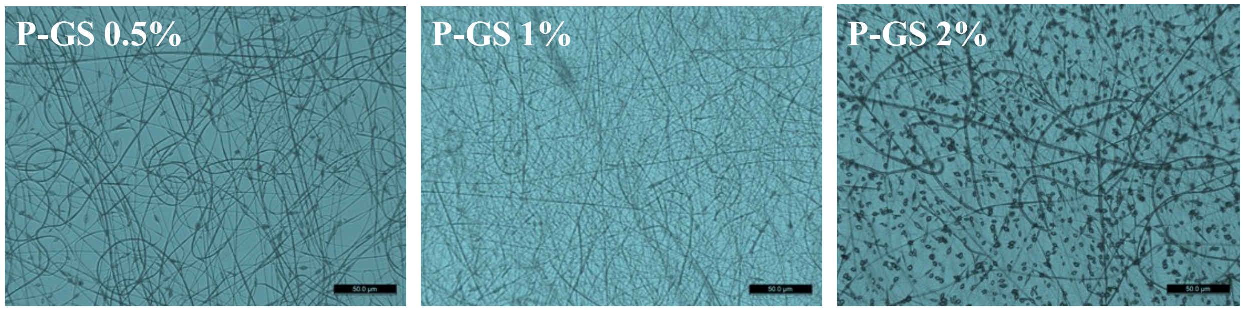
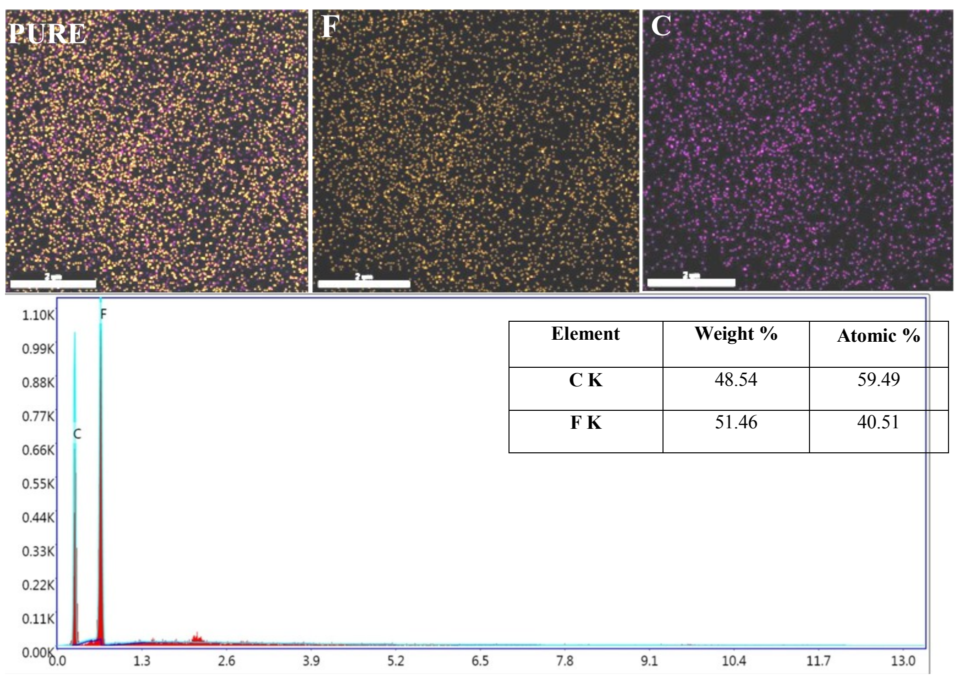


Figure S6**: Optimization of the filler at different concentration w.r.t polymer.**

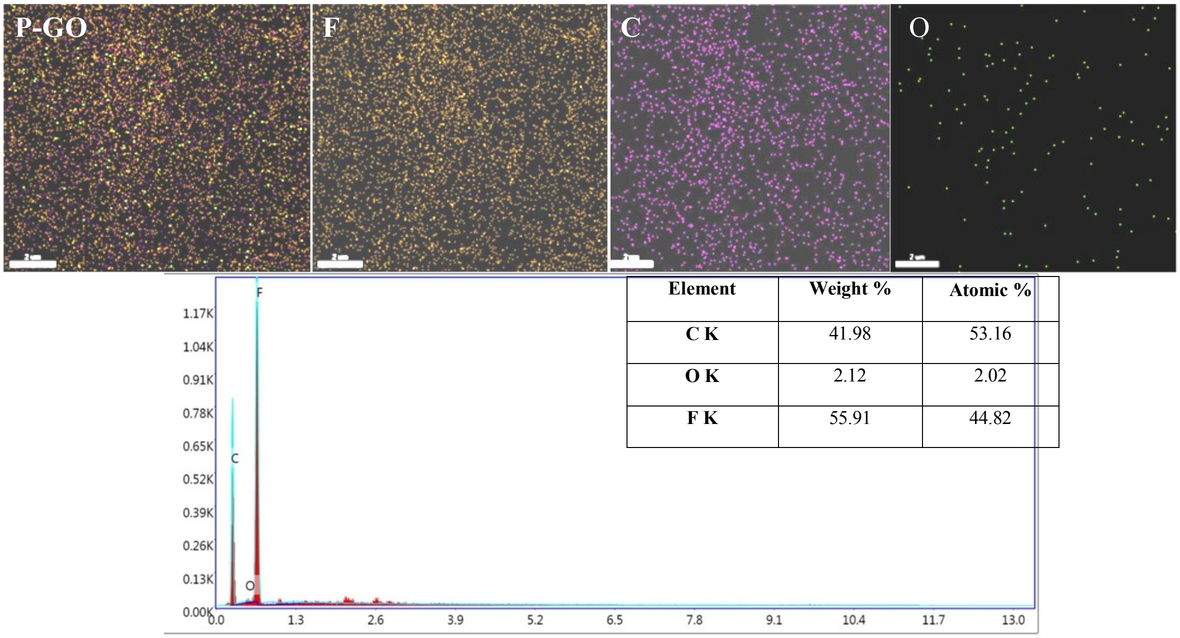
The concentration (wt. %) of the fillers (GO and GS) was optimized at different ratios keeping the electrospinning parameter same and from the POM images, 1% was chosen to be the appropriate concentration for the nanohybrid preparation.

a)



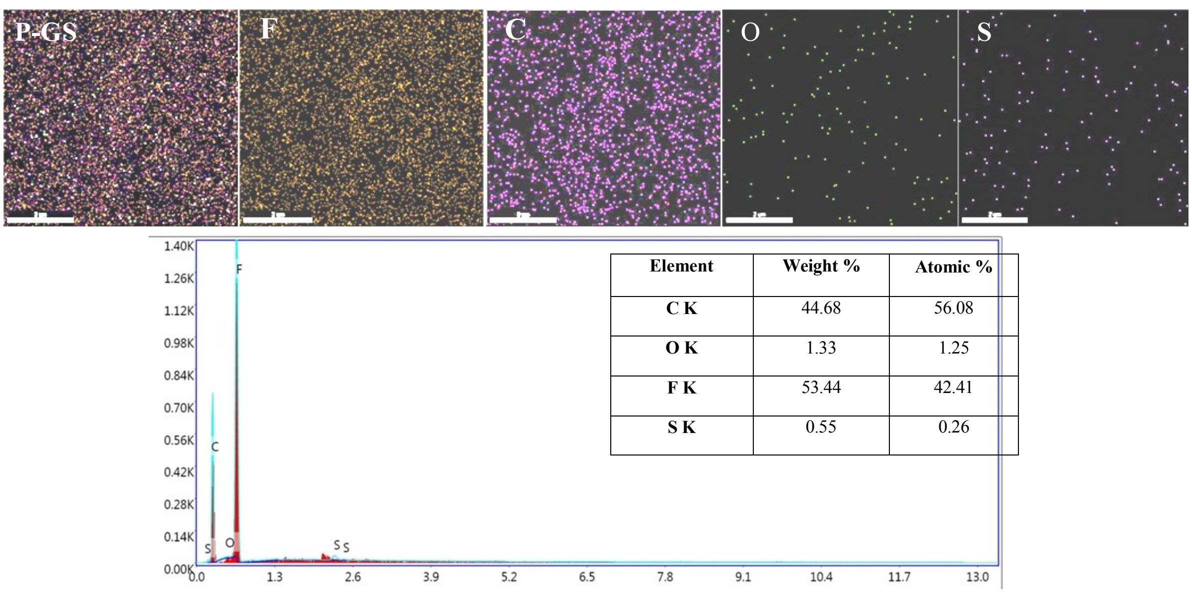
Element	Weight %	Atomic %
C K	48.54	59.49
F K	51.46	40.51

b)



Element	Weight %	Atomic %
C K	41.98	53.16
O K	2.12	2.02
F K	55.91	44.82

c)



Element	Weight %	Atomic %
C K	44.68	56.08
O K	1.33	1.25
F K	53.44	42.41
S K	0.55	0.26

Figure S7: EDS spectrum and mapping of a) **P** b) **P-GO** and c) **P-GS.**

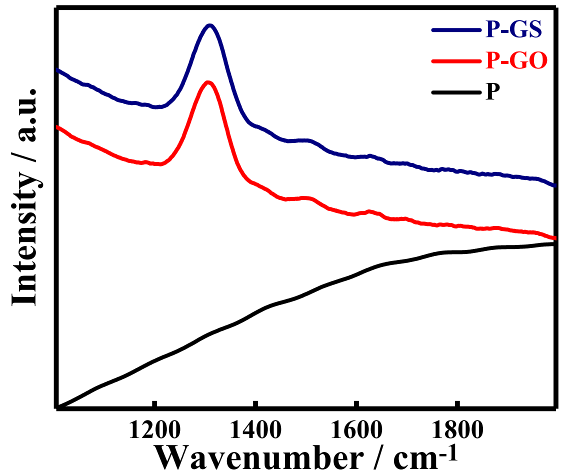


Figure S8**:** Raman spectroscopy of the prepare electrospun scaffold.

The Raman spectroscopy was performed on the electrospun scaffolds and the obtained results suggested that there was incorporation of the prepared fillers (GO and GS) in to the polymer matrix due to the development of two new peaks at1320 and 1535 cm^{-1} which represent the D-band and G-band, respectively. The D-band is obtained due to the distorted structure of the graphene while the G-band arises from the vibrational stretching of the C-C bond in graphite materials.

Applied mechanical stress (Δσ) calculation through finger tapping:

When the object (finger) hits the device, the momentum of the object leads to charge generation. Based on the kinetic energy and momentum theorem, following formula can be deduced to calculate the applied pressure on the device surface:

$$m.g.h = \frac{1}{2}mv^2$$

$$(F - m.g).\Delta t = m.v$$

$$\Delta\sigma = \frac{F}{A}$$

Where m is the mass of the object, g is the acceleration due to gravity, h is the falling height of the object, v is the velocity, Δσ is the applied stress, A is the contact surface area of the device, F is the force of contact, Δt is the time span between two hits.

The average estimated mass of the object (m) ~ 0.48 kg as measured from an electric balance, approximate area (A) over which the pressure was applied ~ 400 mm^2 and Δt ~ 0.05 sec. The average falling height (h) ~ 0.07 m and g = 9.80 N/Kg. Putting the values in the above equations we get an approximate force (F) ~ 16 N. Hence the applied stress (Δσ) ~ 40KPa.

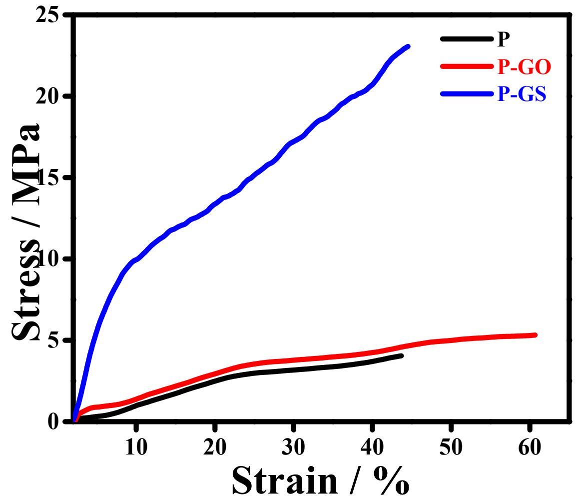


Figure S9: Stress-Strain curve for PVDF and its nanohybrid

Table 1: Mechanical Properties of prepared nanohybrid

Sample	**Young's Modulus (MPa)**	**Toughness (MJ/m^3)**
P	**3.1 ± 0.1**	**0.5 ± 0.05**
P-GO	**30.2 ± 0.5**	**1.3 ± 0.1**
P-GS	**86.1 ± 0.8**	**2.4 ± 0.3**

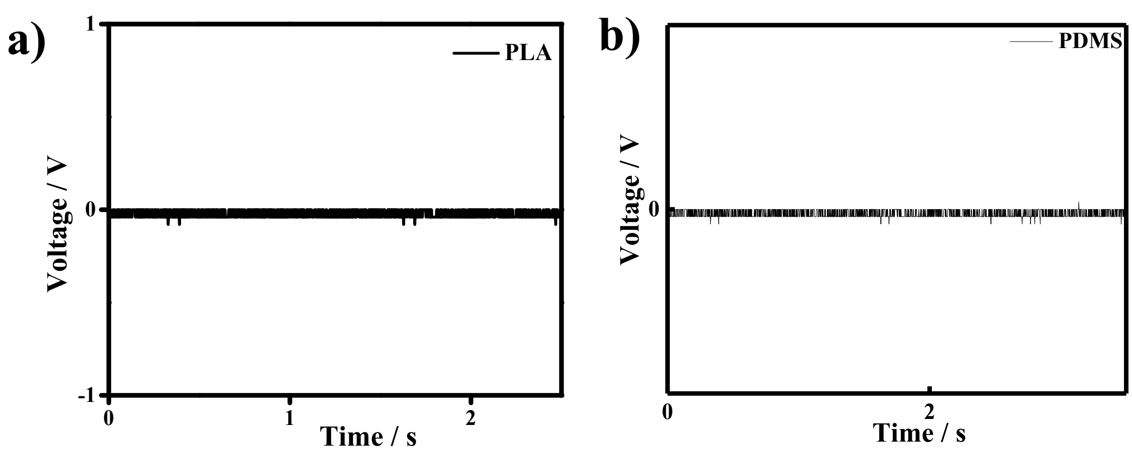


Figure S10: Output voltage response of device prepared from a) scaffold of poly (lactic acid) and b) PDMS

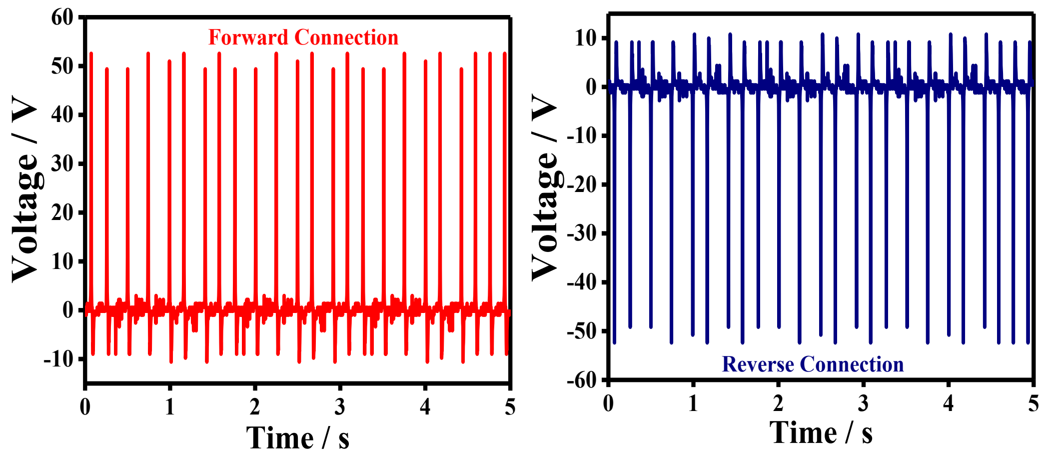


Figure S11: Switching Polarity test has been performed on P-GS to confirm the connection used during measurement.

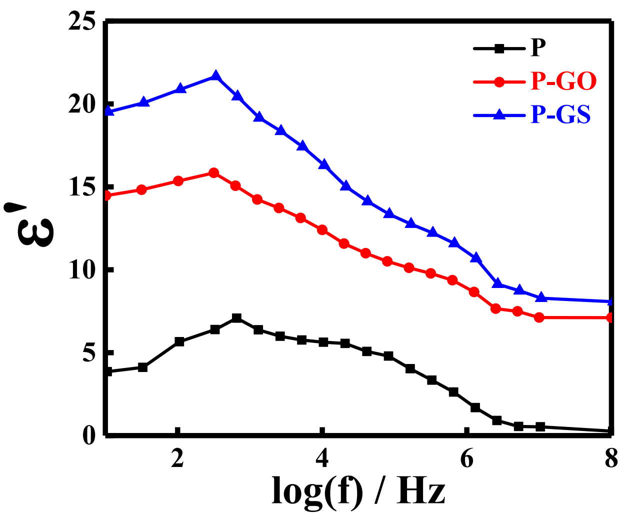


Fig S12: Variation of dielectric constants with frequency for P. P-GO and P-GS.

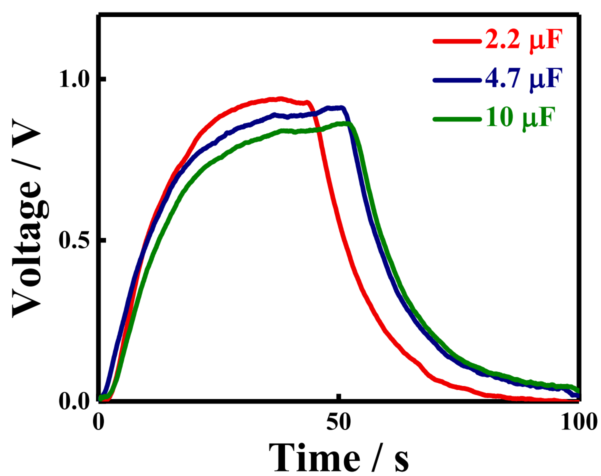
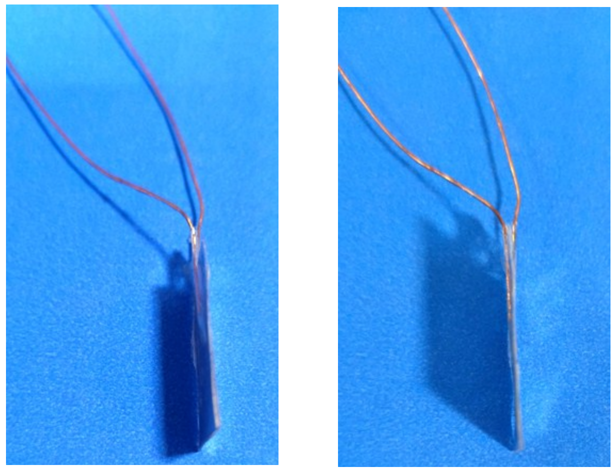


Figure S13: Charging-discharging phenomenon of P-GS at different capacitance.



Before force application **After force application**

Figure S14: The cross sectional view of the device before and after force application.

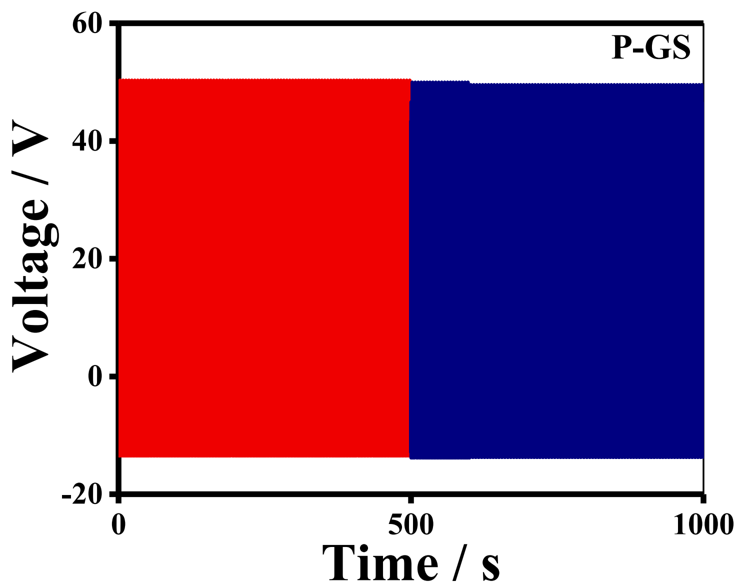


Figure S15: Durability test for P-GS for longer span of time.

The durability of the prepared device was measured at repetitive hitting by finger for 1000s which suggests that the device produced similar response for longer period without much change in the output voltage which confirms the stability of the device.