

## Electronic Supplementary Information

### **Functionalized graphene reinforced thermoplastic nanocomposites as strain sensors in structural health monitoring**

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### **Experimental section**

#### **Preparation of Graphite Oxide**

GO was prepared according to Modified Hummers method. SP-1 (Bay Carbon) graphite was used as the starting material. Briefly, graphite was grounded with NaCl and washed with DI water followed by filtration. After drying, the filtrate was stirred with conc. H<sub>2</sub>SO<sub>4</sub> for 8 h. 6 g of KMnO<sub>4</sub> was gradually added while keeping the temperature less than 20 °C. The mixture was stirred at 35 to 40 °C for 30 min and 65 to 80 °C for 40 min. 92 ml water was added to the above solution and heated to ~ 100 °C. This was diluted by adding 280 ml of water followed by the addition of 30% H<sub>2</sub>O<sub>2</sub>. The mixture was washed followed by repeated centrifugation and filtration (first by 5 % HCl and then with water). The final product was washed and dried in vacuum. <sup>1</sup>

## Characterization Techniques

Field emission scanning electron microscopy (FESEM, Quanta 3D) imaging was used to examine the morphology of the synthesized samples. Samples were mounted on a standard aluminium specimen stub using double sided conductive carbon tape. The microscope was operated at an accelerating voltage of 5-30 kV depending on different imaging purposes. EDX spectra was recorded with Li doped Silicon X-ray detector equipped with FESEM. High resolution micrographs were obtained with FEI Tecnai G<sup>2</sup> transmission electron microscope operated at 200 keV. The samples were dispersed in ethanol and drop cast over holey carbon coated copper grid (200 mesh). The samples were dried over night in ambient atmosphere. The XRD measurements were performed with a PANalytical X'Pert Pro X-ray diffractometer with nickel-filtered Cu K $\alpha$  radiation as the X-ray source. The pattern was recorded in the 2 $\theta$  range of 5° - 40° with a step size of 0.016°. Raman spectroscopy was performed on Witec Raman microscope using green (532 nm) laser excitation, with excitation energy of 2.33 eV. Scans were taken on an extended range (500-3000 cm<sup>-1</sup>) for an exposure time of 60 s. The samples were sprinkled over cleaned glass slides for observation and viewed under a maximum magnification of x20. FTIR was performed on Perkin Elmer spectrum one spectrometer in the range of 400-4000 cm<sup>-1</sup> using KBr pellet method.

## FTIR analyses

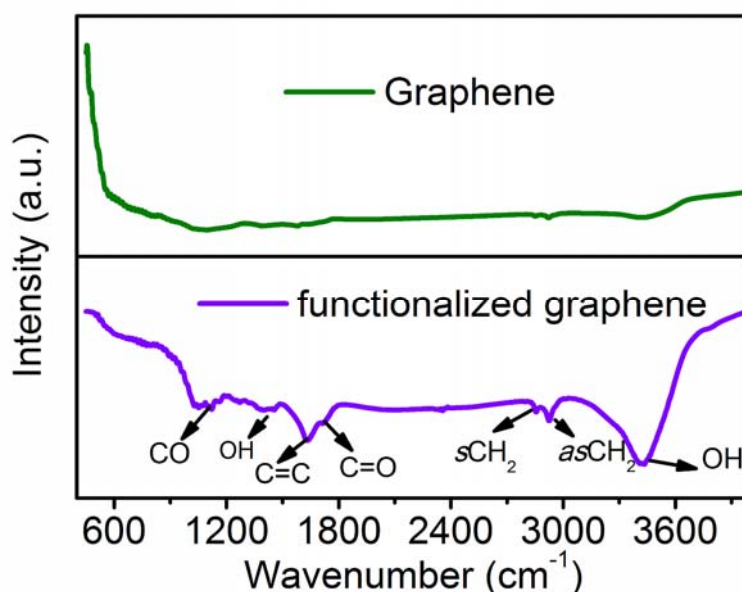


Figure S1: FTIR spectra of graphene and functionalized graphene

Figure S1 shows the comparative FTIR spectra of graphene and functionalized graphene. It confirms the presence of functional groups after functionalization.<sup>2</sup>

### Raman Fingerprints

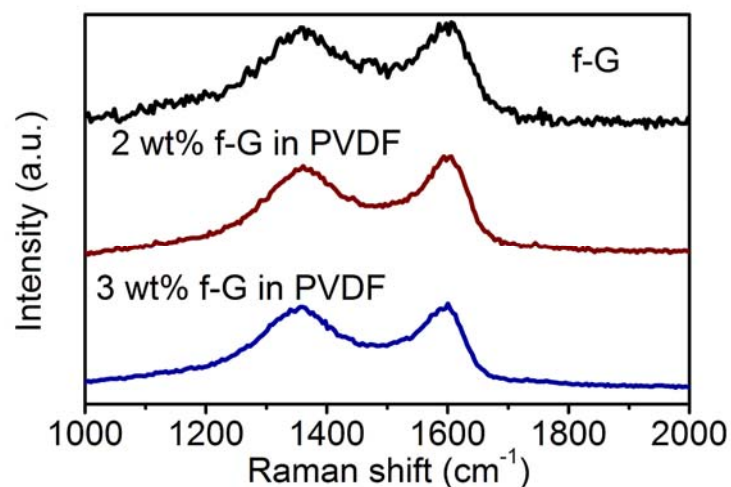


Figure S2: Raman spectra of f-G, 2 wt% f-G/PVDF and 3 wt% f-G/PVDF composite

Figure S2 shows the Raman spectra of f-G, 2 wt% f-G/PVDF and 3 wt% f-G/PVDF composite. It shows the well known D and G-band at their respective Raman shifts. In order to confirm the existence of f-G in the polymer, we have taken Raman spectra of polymer composite and it is shown in figure S2, it shows the signature of graphene.

### Electrical conductivity

Two probe method was employed for measuring electrical conductivity of the graphene polymer composites with higher resistance where as for conducting materials, collinear four probe technique was used in order to avoid contact resistance, lead resistance etc. Positive constant

current was applied to the 1<sup>st</sup> and 4<sup>th</sup> terminal and corresponding voltage was measured between 2<sup>nd</sup> and 3<sup>rd</sup> terminals. Similarly negative constant current was applied and corresponding voltage was measured. Positive and negative currents were applied in order to avoid voltage generation due to thermoelectric effects.

Two probe technique, electrical resistivity ( $\Omega\text{-m}$ )

$$R = \frac{\rho l}{A} \text{-----} (1)$$

Where R is the measured resistance between the two probes ( $\Omega$ )

l is the probe separation (m)

and A is the area of current distribution ( $\text{m}^2$ )

Four point collinear probe technique

$$\rho = \frac{\pi t}{\ln 2} \frac{(V_+ - V_-)}{2I} k \text{-----} (2)$$

Where  $\rho$  is electrical resistivity ( $\Omega\text{-m}$ )

t is the thickness of the sample (m)

I is the applied current (A)

$k = k_1 k_2$  is the correction factor due to finite size and dimensions

$V_+$  is the measured voltage for applied positive current (V)

$V_-$  is the measured voltage for applied negative current (V)

Reciprocal of resistivity is known as conductivity ( $\sigma$ )

$$\sigma = \frac{1}{\rho} \text{ (S/m)} \text{----- (3)}$$

## References

1. V. Eswaraiah, S. S. Jyothirmayee Aravind and S. Ramaprabhu, *J. Mater. Chem.*, 2011, **21**, 6800-6803.
2. F. OuYang, B. Huang, Z. Li, J. Xiao, H. Wang and H. Xu, *The Journal of Physical Chemistry C*, 2008, **112**, 12003-12007.