Supplementary Materials

S1: Electrical measurement

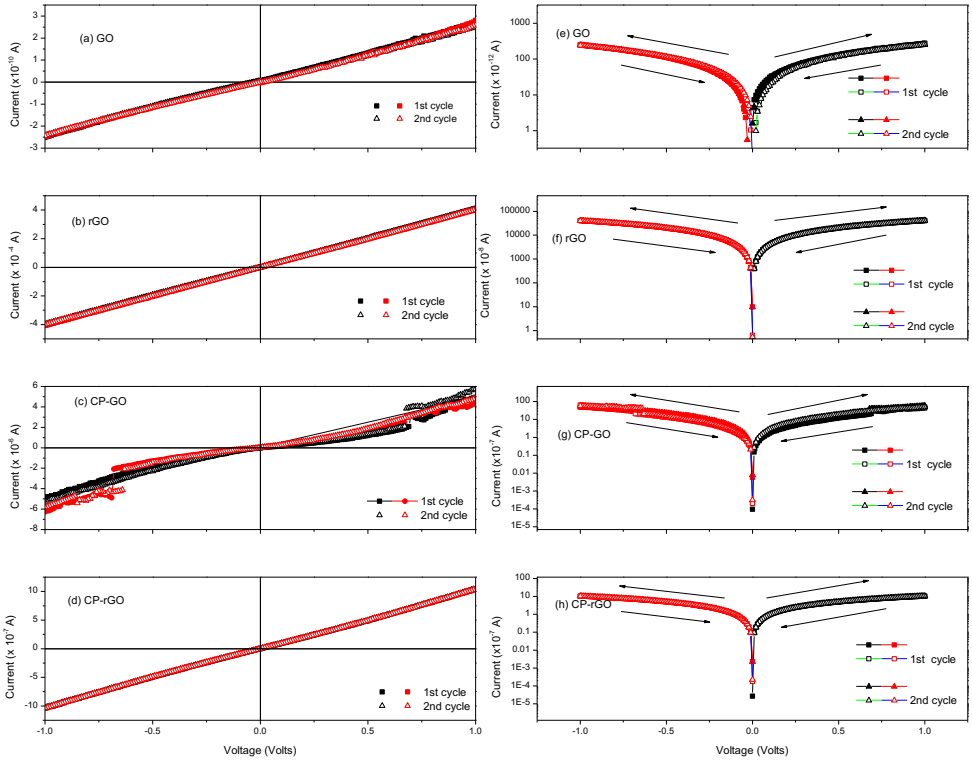

FIG. S1 *Linear current (I)–voltage (V) relationship for (a) GO, (b) r-GO, (c) CP-rGO and (d) CP-rGO samples with the corresponding log (I)–(V) relationship shown in (e-h) respectively.*

Electrical properties were measured using a Keithley 6487 Picoammeter/Voltage Source with sweep voltage ranging from -1 to 1 V was used. The technique employed to make contacts was a two-point probe resistance measurement method. The thin film samples were made to be of the same size, shape and thickness so that an unbiased comparison will be made of their I-V relationships. As for electrical measurement, sheet resistance for GO, rGO, CP-GO and CP-rGO was measured to be 4 x 10^9 Ω, 2 500 Ω, 1 x 10^5 Ω and 9 x 10^5 Ω respectively. It

must be noted that the sheet resistance of rGO decreased upon reduction as compared to that of GO. Also, the PEDOT-PSS-coated GO recorded a lower sheet resistance as compared to the starting GO due to incorporation of PEDOT-PSS a conducting polymer. However, our study is more interested in conduction mechanisms and hence we will dwell more on I-V measurements. The linear current-voltage (I-V) relationship for GO, rGO, CP-GO and CP-rGO were recorded (**FIG. S1(a- d)**) by sweeping the voltage in the sequence 0 → +1 → 0 → -1 → 0 V using a step voltage of 0.01 V. As anticipated, GO was highly insulating and displayed a poor conductivity due to heavy oxidation of its carbon lattice. The rGO films recorded an enhanced current response (~10^6 times higher than GO) due to removal of oxygen functional groups and a subsequent increase in the sp^2 content as verified and confirmed from the results obtained by XANES and Raman spectroscopy. Upon coating GO with a conducting polymer PEDOT-PSS (CP-GO), the resulting film seized to be insulating and rather conducting behaviour was shown with a relatively higher current response (~10^4 times higher than GO) due to increase in the sp^2 content of the films and subsequent decrease in the oxygen functional groups as reveals from XANES and XPS results. Nevertheless, CP-rGO showed a lower current response (~10^4 times less than r-GO) due to formation of extended polymer chains blocking the charge flow and a higher sp^3 content (see Table I)[1]. Unexpectedly, CP-rGO showed a relatively lower current response that is ~9 times less than that of CP-GO due to a relative decrease in the sp^2 content of the films (as supported by XANES). The corresponding log I-V curves for GO, rGO, CP-GO and CP-rGO are displayed in **FIG. S1(e-h)** whereby GO displayed a symmetric log I–V curve which have a small hysteresis loop on the positive voltage side and ranges between 0 V to 0.5 V, whereas the CP-GO also shows a small hysteresis loop on both (negative and positive) voltage sides in the range 0.0 to 0.75 V. The hysteresis effects usually arise from deeply trapped charges owing to the presence of defects in the CP-GO since the escape time for the trapped charges is longer

than the time it takes to make the semi-log sweep[2]. The successful electrical tuning of our PEDOT-PSS-coated samples is of utmost importance in biomedical applications such as biosensors and MRI. In cell-based electrical sensors, the physiological stress on cells after exposure to alcohols cause a change in cell volume that can be observed in the electrical signal through graphene. These change in the cell volume leads to straining of the graphene sheets, forming wrinkles thereby reducing the electrical conductivity[3]. Also, in MRI conductivity largely vary as a function of relative intracellular and extracellular fluid volumes and ionic concentrations.

References

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