Electronic Supplementary Information

Materials

Graphite powder with particle size <20 µm, concentrated sulfuric acid (H_2SO_4, 98%), potassium persulfate ($K_2S_2O_8$), phosphorus pentoxide (P_2O_5), hydrochloric acid (HCl), potassium permanganate ($KMnO_4$), and hydrogen peroxide (H_2O_2, 30%), were all obtained from Sigma–Aldrich Co. Ltd. Polyester, Nylon, Glass fibers and Aramid were obtained from GURIT while wool, cotton and Tide detergent were purchased from the local market. All of the materials were directly used without further purification.

Preparation of GO

The graphite powder (2 g) was put into concentrated H_2SO_4 (50 ml) with ice bath. $KMnO_4$ (7 g) was added gradually with stirring, and the temperature of the solution was kept below 10 °C. The mixture was then stirred at 35 °C for 2 h and DI water (96 ml) was added. The solution was stirred for another 30 min, the reaction was then terminated by adding 300 ml of DI water and 5 ml of 30% H_2O_2 solution. The mixture was centrifugation and subjected to several cycles of suspension in 5% HCl solution and separated by centrifugation. In order to completely remove metal ions and acids, the graphite oxide was subjected to cycles of washing with DI water and separation with centrifugation until the pH value of the supernatant reached 6. The GO product was suspended in distilled water to give a viscous, brown dispersion (15 mg/ml).

Preparation of GO coated fibers

Each rGO cladded fiber and fiber mat specimens were prepared by immersing the specimen in a 0.37 mg/ml rGO suspension, drying on a hydrophobic substrate (such as Polytetrafluoroethylene or Polyvinylidene fluoride), reducing chemically via hydrogen iodide or hydrazine and finally washing with DI water until the reducing agent is completely washed out.

Characterization

FEI Quanta FEG 250 scanning electron microscopy was used for studying the morphology of the samples. MFP-3D Atomic Force Microscope (AFM) was used to obtain the topographical image of single layer graphene oxide (GO) sheets. Ultrasonication was done by WiseClean ultrasonic bath (WUC-D22H, frequency 40 kHz, 300 W) at room temperature (RT).
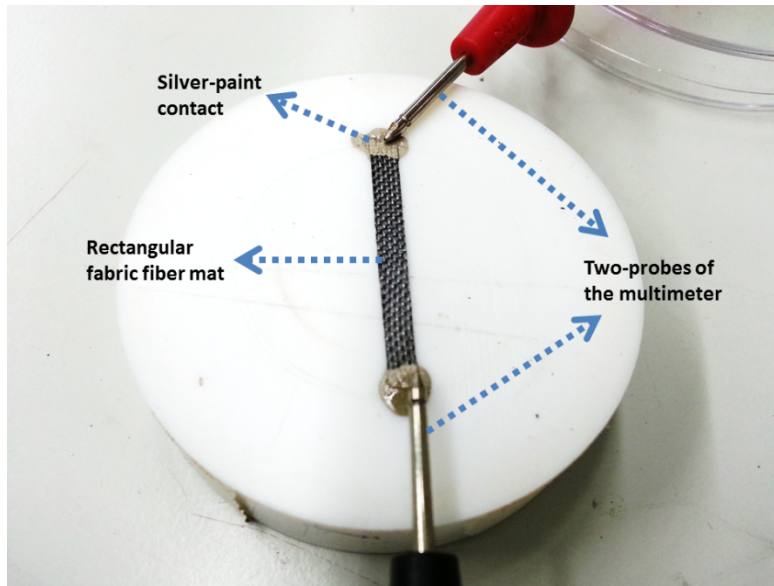
Figure 1: Two-point probe setup

Electrical conductivities

Electrical measurements of the fibers and fiber-mats before GO cladding were estimated using the Tongui TH2684A insulation resistance meter whereas the electrical conductivities of the specimens after cladding were measured using a DT-930 voltmeter. As shown in Figure 1, Rectangular specimen of equal areas (length: 30mm, width: 4mm) were cut from the fiber mats before and after coating and the measurements were taken using an insulation resistance meter and a digital voltmeter for samples before and after graphene cladding respectively. Electrical conductivity measurements were taken using a two-point probe technique reported also elsewhere for similar materials [1]. Five readings were taken for each sample and the average readings are tabulated in Table 1 along with the errors.

Table 1

Material		Nylon	Polyester	Cotton	Wool	Kevlar	Glass
Electrical Conductivity (S/cm)	**Before cladding**	6E-12 +/-0.2E-12	2.8E-10 +/-0.5 E-10	2.5E-11 +/-0.8 E-11	2.3E-11 +/-1 E-11	4.8E-13 +/-0.3 E-13	3E-12 +/-0.5 E-12
	After cladding	4.5 +/-0.4	0.1 +/-0.02	0.04 +/-0.001	0.01 +/-0.002	13 +/-5	0.6 +/-0.05

AFM Topographical image of GO sheets

The GO used for cladding were obtained using the modified hummer's method. An AFM topographical image was taken for single layer GO spread on a silicon substrate as shown in Figure 2. The surface roughness scan in figure 1 shows a height variation of 1-2nm which signifies the presence of single or at most double layer GO sheets.
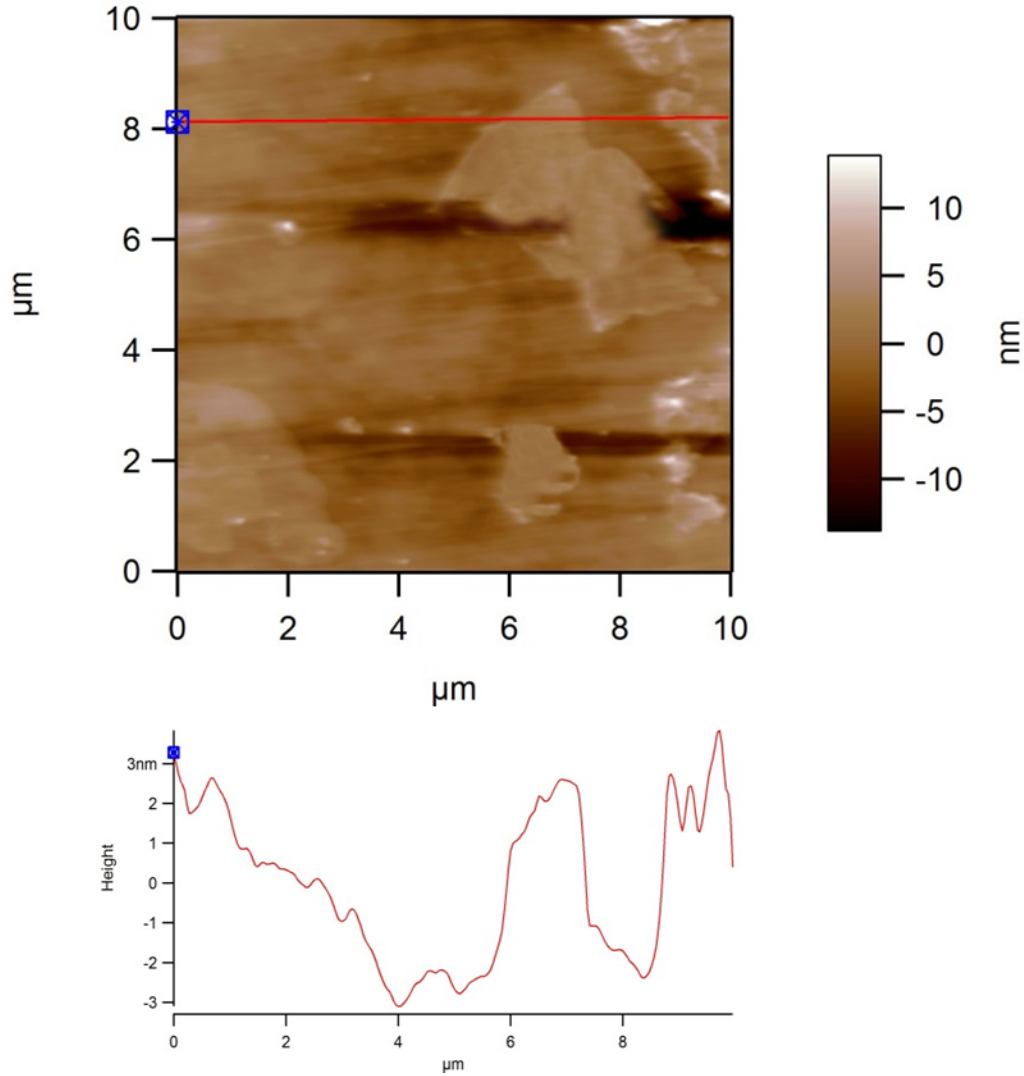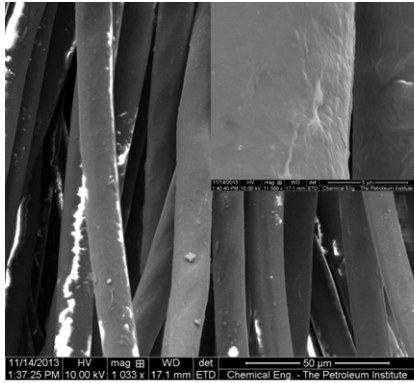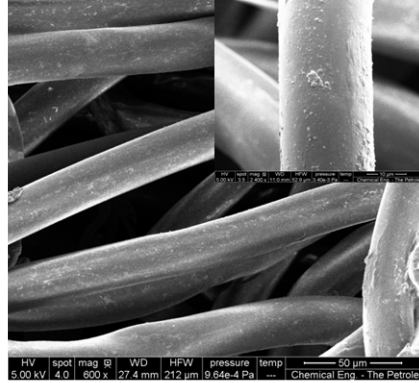

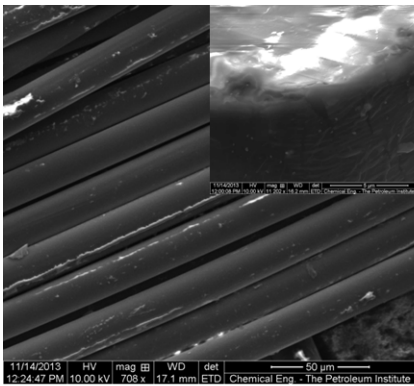Figure 2: Single layer graphene oxide (GO) sheets in AFM
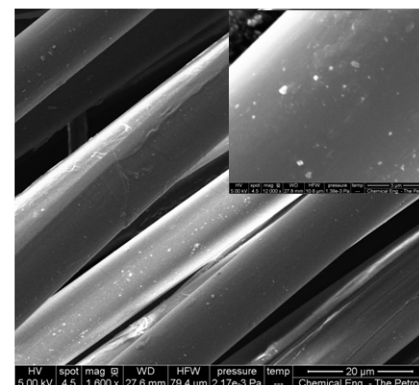
SEM images of specimen
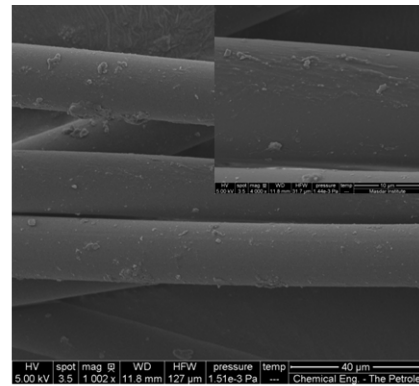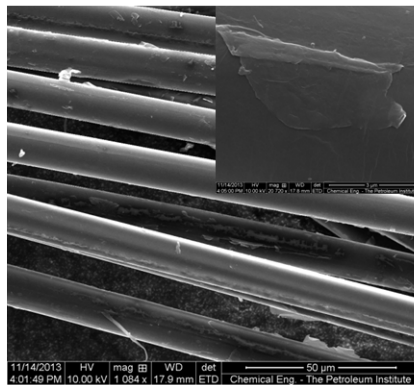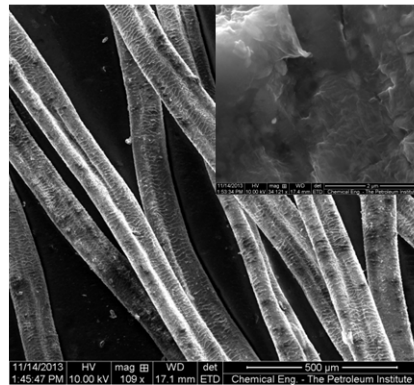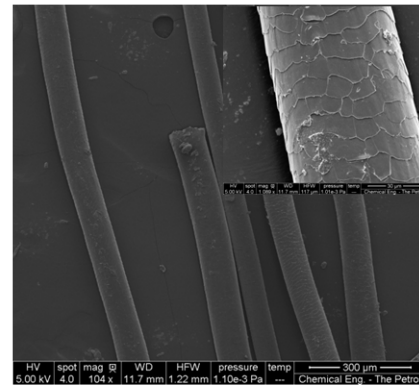

Figure 3: a, c, e and g are the SEM images of the of rGO cladded cotton, Nylon, Aramid, and wool samples respectively along with the morphology of individual fibers shown as insets whereas b, d, f and h are the SEM images and pristine cotton, Nylon, Aramid, and wool samples respectively along with the morphology of individual fibers shown as insets.

Effect of GO concentration

The effect of GO concentration on the electrical conductivities of Nylon and Polyester fibers mats were studied using GO concentrations of 1mg/ml, 2mg/ml and 5mg/ml besides the as prepared 0.37mg/ml. The electrical conductivity of Nylon increases from a mere 4.5 S/cm to about 12 S/cm when the GO concentration is increased from 0.37mg/ml to 5mg/ml. However, the increase is not linear throughout as shown in figure 4. When the concentration of GO is increased from 0.37mg/ml to 1mg/ml, there is no significant increase in the electrical conductivity. However, when GO concentration is increased to 2mg/ml, there is a significant jump in electrical conductivity as it almost doubles. This jump is due to the formation of scales on the Nylon fiber mat as shown in the inset of figure 3. Later, there is no substantial difference in electrical conductivity when the concentration of GO is raised from 2 to 5mg/ml. Polyester shows a different behaviour than the Nylon as there is a large jump in electrical conductivity when the GO concentration is raised from the as prepared 0.37 to 1mg/ml. Therefore, it forms scales in a lower concentration of GO than Nylon. Later, it shows a linear behaviour up till a GO concentration of 5mg/ml. Therefore, it can be said that different fiber and fiber mats start forming scales on the surface at different GO concentrations. However, with the as prepared GO concentration of 0.37mg/ml, no sample shows any scaling as evident from the SEM images in figure 3.
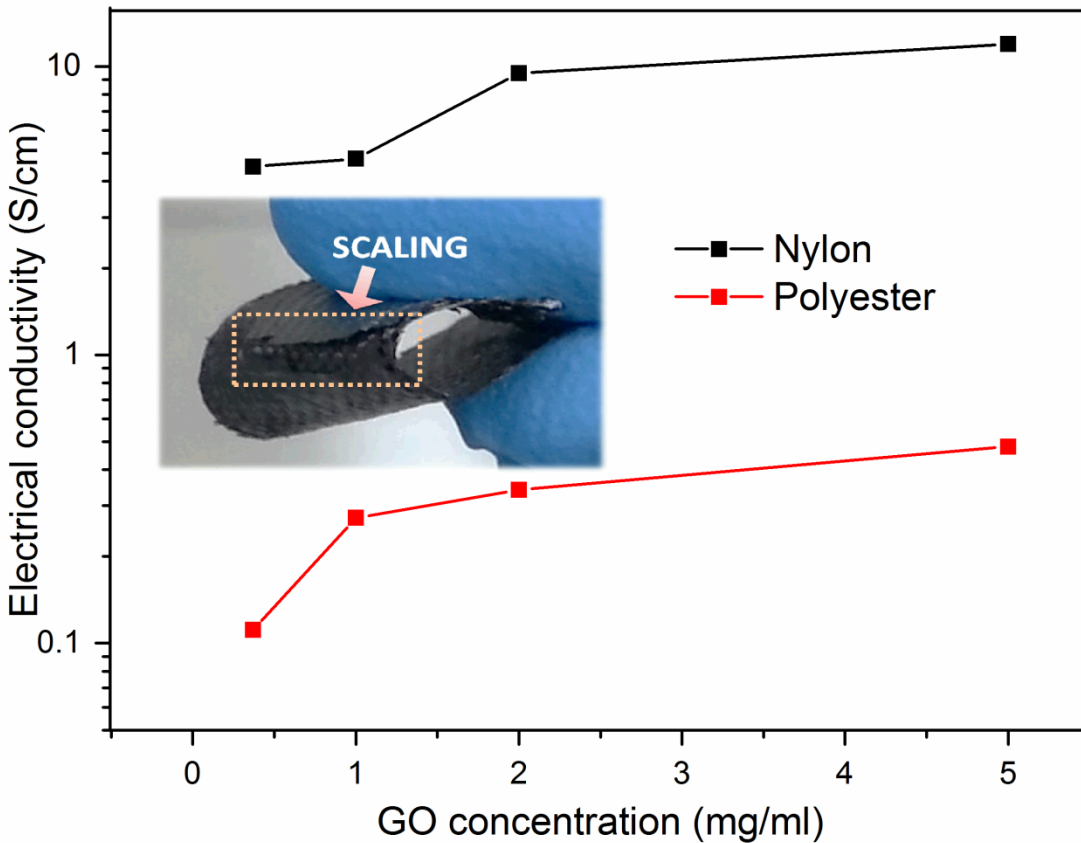

Figure 4: Effect of GO concentration on the electrical conductivities of Nylon and Polyester fiber mats.

[1] a) H.-B. Zhang, W.-G. Zheng, Q. Yan, Y. Yang, J.-W. Wang, Z.-H. Lu, G.-Y. Ji and Z.-Z. Yu, *Polymer* **2010**, *51*, 1191-1196; b) S. Stankovich, D. A. Dikin, R. D. Piner, K. A. Kohlhaas, A. Kleinhammes, Y. Jia, Y. Wu, S. T. Nguyen and R. S. Ruoff, *Carbon* **2007**, *45*, 1558-1565; c) L. Hu and Y. Cui, *Energy & Environmental Science* **2012**, *5*, 6423-6435; d) L. Hu, M. Pasta, F. L. Mantia, L. Cui, S. Jeong, H. D. Deshazer, J. W. Choi, S. M. Han and Y. Cui, *Nano Letters* **2010**, *10*, 708-714.