Supplementary Information

Stable dispersions of graphene and highly conducting graphene films: a new approach to creating colloids of graphene monolayers

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1. Synthesis of Graphite Oxide (GO)

Graphite oxide (GO) was prepared by natural graphite as the modified Hummers' method. In a typical reaction, 1 g of natural graphite, 1 g of $NaNO_3$ and 46 mL of concentrated H_2SO_4 were stirred together in an ice bath for 4 h. Next, 6 g of $KMnO_4$ was added slowly. Once mixed, the ice bath was removed and the suspension was stirred for 2 h. After adding 92 mL of pure water dropwise, the suspension was heated in a water bath at 98 ^oC for 15 min. Then the suspension was further treated with 200 mL of warm water and 20 mL of H_2O_2 (30%) in sequence. The mixture was centrifuged at 4000 rpm and washed with HCl and water. Finally, GO was dried at 50 ^oC for 48 h.

2. Instruments

X-ray diffraction (XRD) analyses were performed using a X' Pert Pro system with Cu Kα radiation (λ =1.54060 Å) operated at 40 kV and 40 mA. The

morphologies of the graphene film were investigated by JSM 6700-F FESEM (JEOL). Transmission electron microscopy (TEM) and selected area electron diffraction (SAED) studies were carried out using a TECNAI F30 TEM operating at an accelerating voltage of 300 kV. Atomic force microscopic (AFM) images were taken out using a Nanoscope III MultiMode SPM (Digital Instruments) operated in tapping mode in conjunction with a V-shaped tapping tip (Applied Nanostructures SPM model: ACTA). The images were taken at a scan rate of 2 Hz. X-rays photoelectron spectroscopy (XPS) spectrums were recorded on a PHI Quantear SXM (ULVAC-PH INC) which used Al as anode probe in 6.7×10^{-8} Pa. Raman spectra were obtained on a RM 2000 microscopic confocal Raman spectrometer (Renishaw in Via Plus, England) employing a 514 nm laser beam. Fourier transform infrared spectroscopy (FTIR) spectrums were measured using a Nicolet IR100 FT-IR spectrometer with pure KBr as the background. UV-vis spectrums were detected using Ultraviolet spectrophotometer (Hitachi UV2800).

3. XRD

The XRD patterns of GO, cleaned G and G film on ITO are shown in Fig. S1. The peak of GO at 10-11° disappears and the board peaks are observed in both G and its film on ITO, confirming that GO was reduced. The remained peaks in the graphene film are consistent with the ones of the ITO.

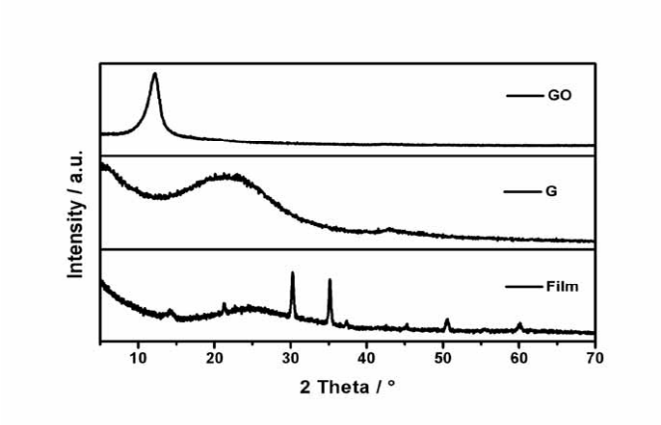


Fig. S1 XRD patterns of GO, cleaned G and G film on ITO.

4. XPS

Fig. S2a shows the full XPS spectrums of GO and cleaned G. Through analyzing the N1s of the cleaned G in Fig. S2b, the main peak of N is attributed to "graphene N" (398.1 eV) according to the standard spectrums and the other peak is possibly associated with N-H (399.3 eV) from absorption of oxidation product of para-phenylene diamine (OPPD).

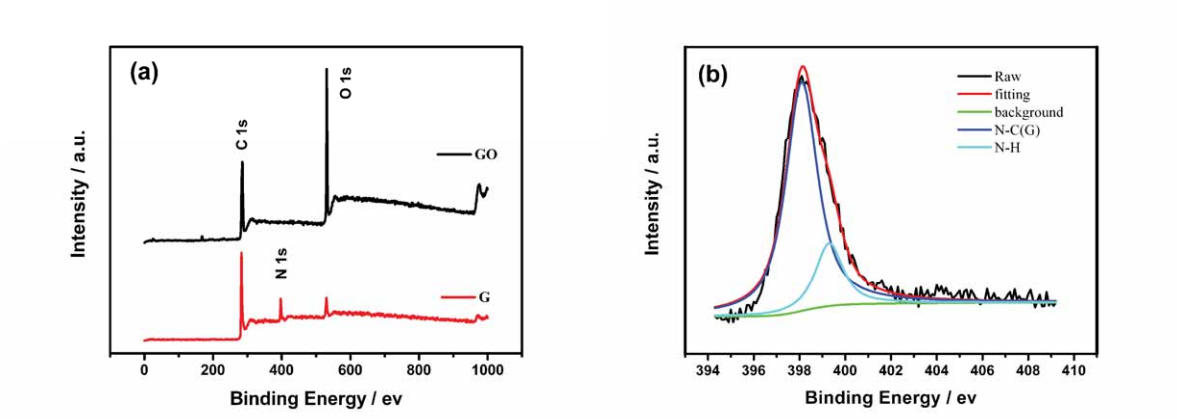


Fig. S2 XPS spectrums and analysis.

(a) the full XPS spectrums of GO and cleaned G,

(b) N1s XPS of cleaned G.

5. FTIR

The FTIR spectrum of cleaned G and GO are presented in Fig. S3. As we know, GO is composed of hydroxyl and aether groups on both sides and carboxyl ones on the edge. The bands at 1049 cm^{-1} and 1727 cm^{-1} are attributed to C–O in hydroxyl and C=O in carboxyl groups. The bands at 1224 cm^{-1} and 833 cm^{-1} are associated with symmetrical and asymmetrical stretching vibration of aether groups. However, no absorption bands observed suggests that the function groups in the cleaned G are below the detection limit of FTIR.

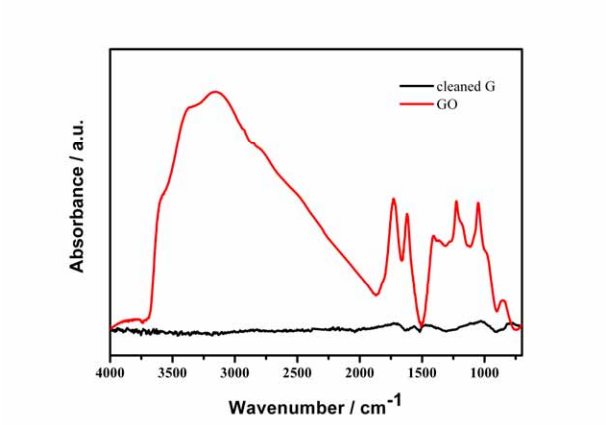


Fig. S3 FTIR spectrum of cleaned G and GO.

6. Raman

The Raman spectrums of Graphite, GO and cleaned G are shown in Fig. S4a. The Raman spectrum of GO is intervened by fluorescence. The Raman peaks of cleaned G are obtained by fitting (Fig. S4b). The peaks from left to right are signed as P1, P2, P3, P4 and P5. P2 and P5 are fixed as D band (1356cm^{-1}) and G band (1580cm^{-1}). P1 (1262cm^{-1}) may be caused by C-N in graphene. P3 and P4 are possibly attributed to small domains of aromaticity and symmetry C=C respectively. The D/G ratio in

intensity of G is 0.65 and it is lower than 0.78 of GO.

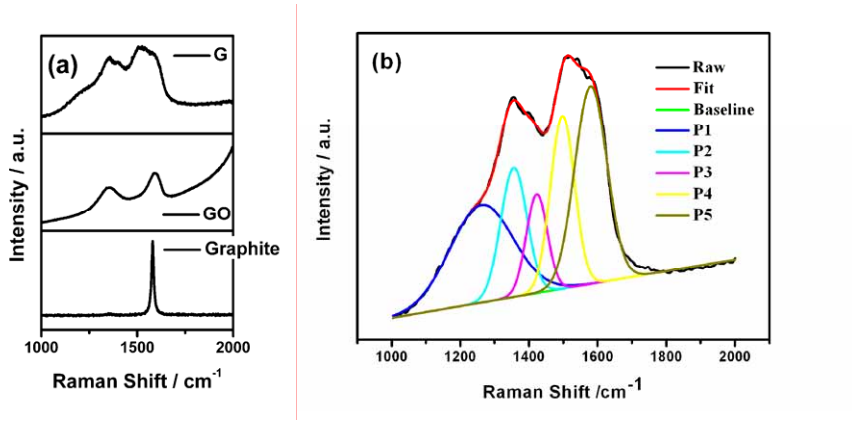


Fig. S4 Raman spectrums and analysis.

(a) Raman spectrums of graphite, GO and cleaned G,

(b) the fitting result of Raman of cleaned G.

7. Film

The film deposited on ITO can be taken off from the substrate to become a freestanding film after it is dipped in 1 M HCl aqueous solution. Fig. S5 shows the photos of the graphene film on the ITO glass and the freestanding film. Scheme S1 is a diagram of the electrophoretic deposition process to prepare graphene films.

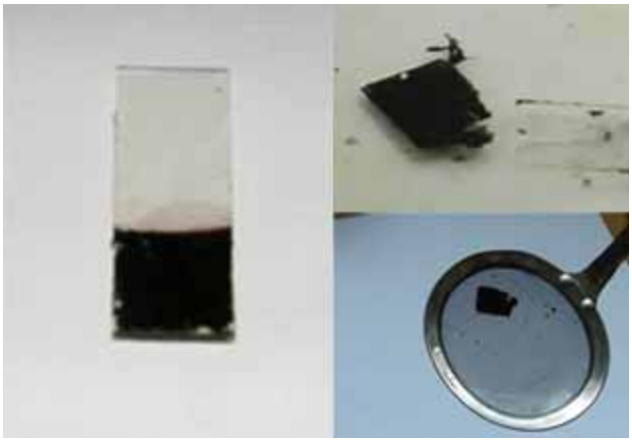
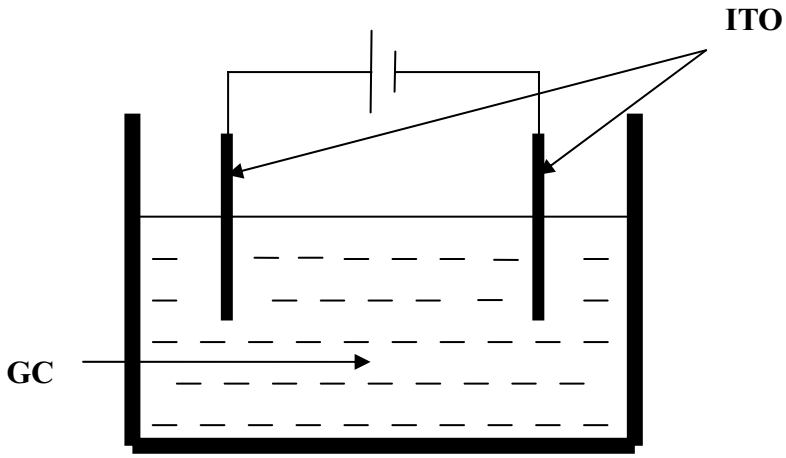


Fig. S5 Photo of the graphene film on ITO and the freestanding film.



Scheme S1 Diagram of electrophoretic deposition process.