Fabrication of high quality reduced graphene oxide sheets via a two-step reduction of graphene oxide

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Graphene oxide (GO) is an astonishing material with promising applications in different fields and more importantly, it is used as a precursor to fabricate graphene-like materials. However, an efficient reduction method to obtain reduced graphene oxide (RGO) sheets with high structural qualities is in demand. Attempts have been made to achieve this by changing reduction strategies, and most recent reports claimed to acquire high quality RGO using catalysts [1], microwave reduction [2], and oxidation of graphite to get less defected graphene oxide [3]. Still, these methods are either energy and time consuming or result in low yield. Hence, the challenge is still open to synthesize high quality RGO in a more easy and productive way. Here, we report a two-step reduction of GO, which resulted in RGO with high structural quality. As given the schematic in Fig. 1(a), reduction of GO was first done chemically using a mixture of hydroiodic acid and trifluoroacetic acid (HI/TFA) within a few minutes and secondly by thermal annealing in the presence of ethanol at 800 ºC. Ethanol acts as an agent of lattice defects restoration during thermal annealing step [4]. Raman spectrum of the obtained RGO sheets shows a low intense D-band and a high intense G'-band. All the peaks are very sharp as can be seen in Fig. 1(b). Using the following equations and based on the peak widths and I_D/I_G ratio, the distance between defects (L_D) in the graphene lattice was calculated [5]. The L_D values for GO, only chemically reduced GO, and only thermally reduced GO were all less than 2 nm (equation 1), while for GO reduced via two-step reduction it is about 21 nm (equation 2). Following this reduction strategy, we could fabricate highly conductive and transparent RGO films, which further confirms the quality of the synthesized RGO films is of high quality.

$$L_D^2\,(nm)^2 = 5.4\times10^{-2}\,E_L^4(eV^4)\frac{I_D}{I_G} \qquad (1)$$

$$L_D^2\,(nm)^2 = \frac{4.3\times10^3}{E_L^4\,(eV^4)}\left[\frac{I_D}{I_G}\right]^{-1} \qquad (2)$$

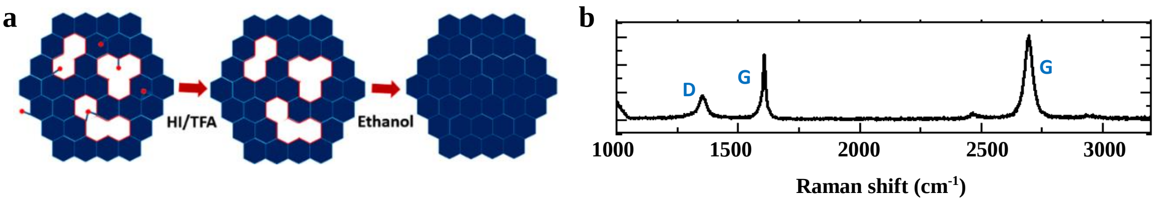

Fig. 1 (a) Schematic showing the two-step reduction of GO, (b) Raman spectrum of the high quality RGO sheets.

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