Supporting Information

Two Dimensional Graphene Bridges Enhanced Photoinduced Charge Transport in Dye-Sensitized Solar Cells

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1. XRD Patterns of Graphite, GO, and Graphene

Figure S1 shows the XRD patterns of flake graphite, GO and graphene, respectively. The pattern of graphite has a peak centered at $2\theta = 26.6^\circ$, corresponding to a d-spacing of 3.34 Å (**Figure S1a**), which is absent in the GO sample (**Figure S1b**). While a new peak at $2\theta = 12.1^\circ$ is arisen, corresponding to the (002) inter-planar spacing of 7.30 Å. So graphite has been exfoliated and pristine GO was formed. After reducing GO in hydrazine vapor, the basal spacing decreases from 7.30 Å of the pristine GO to 3.56 Å in the reduced samples (**Figure S1c**), indicating that graphene has been successfully obtained.¹

Figure S1. XRD Patterns of (a) Graphite, (b) GO, and (c) graphene

2. XPS Data.

The C 1s XPS spectrum of GO (**Figure S2a**) indicates the presence of four types of carbon bonds: C-C (284.8 eV), C-O (286.8 eV), C=O (287.5 eV), and O-C=O (289.0 eV). Although Electrode **2** has the same C 1s species (**Figure S2b**), the intensities of oxide species are much weaker. Besides, there is an additional peak at 285.8 eV, corresponding to the C in the C=N bonds of hydrazone.

Figure S2. The C 1s XPS spectrum of (a) GO and (b) Electrode **2**

The XPS data shows the content of oxygen was decreased after the reduction. The weight loss is oxygen in majority, and the weight loss is about 25% (keep the content of C as a constant). Also, the graphene will lose another 7% weight after calcining at 450 °C in air.² So after the treatment, the GO will have about 70% left.

Table S1. The XPS data of GO.

Name	Start BE (eV)	End BE (eV)	Height Counts	FWHM (eV)	Area (P) CPS.(ev)	At. %	SF
C1s	292.48	281.04	12417.87	2.1	54207.59	67.84	1
O1s	537.73	527.05	24492.12	2.19	60343.76	31.59	2.85
N1s	410.51	394.85	221.41	0.25	755.03	0.57	1.77

Table S2. The XPS data of graphene.

Name	Start BE (eV)	End BE (eV)	Height Counts	FWHM (eV)	Area (P) CPS.(ev)	At. %	SF
C1s	294.2	281.05	46997.54	1.52	108204.5	87.05	1
O1s	538.91	526.54	6680.79	3.46	27021.26	8.53	2.93
N1s	407.49	395.2	2627.7	3.13	9327.07	4.43	1.8

3. FT-IR Spectrum of GO and GR

Figure S3a and **S3b** show the FT-IR spectrum of GO and graphene. In **Figure S3a**, shows the FT-IR spectrum of GO. The spectrum confirms that the graphite has been oxidated successfully. The characteristic vibrations are the broad O-H stretching peak at 3411 cm^{-1} , the strong C=O peak at 1730 cm^{-1} , the 3°-C-OH peak at 1460 cm^{-1} , the O-H deformation peak at 1390 cm^{-1} , the C-OH stretching peak at 1240 cm^{-1} , the C-O stretching peak at 1060 cm^{-1} . The peak at 1622 cm^{-1} is due to the skeletal vibrations of unoxidized graphitic domains. The spectrum of graphene confirms the reduction of GO (**Figure S3b**). The O-H peaks, the C-O peaks and the C=O peak have been decreased. And a new absorption band at 1550 cm^{-1} may be attributed to the skeletal vibration of the graphene sheets. ¹

Figure S3. FT-IR Spectrum of (a) GO and (b) graphene

4. The transmittance of different electrodes

Figure S4 shows the UV-vis spectrum of different electrodes. The Electrode CNT has the highest transmittance.

Figure S4. The UV-vis transmittance spectrum of different electrodes.

References

1. Nethravathi, C.; Rajamathi, M. Chemically Modified Graphene Sheets Produced by the Solvothermal Reduction of Colloidal Dispersions of Graphite Oxide. *Carbon* **2008**, *46*, 1994-1998.
2. Stankovich, S.; Dikin, D. A.; Piner, R. D.; Kohlhaas, K. A.; Kleinhammes, A.; Jia, Y.; Wu, Y.; Nguyen, S. T.; Ruoff, R. S. Synthesis of Graphene-Based Nanosheets via Chemical Reduction of Exfoliated Graphite Oxide. *Carbon* **2007**, *45*, 1558-1565.