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Supporting Information

Multi-functional Au/CdS/Fe_3O_4/RGO Hybrid Nanomaterials with Enhanced Photocatalytic Activity

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Experimental Section：

Synthesis of GO:

GO was synthesized from natural graphite powder according to a modified Hummers method.[25] Briefly, 0.9 g of graphite powder was added into a mixture of 7.2 mL of 98% H_2SO_4, 1.5 g of $K_2S_2O_8$, and 1.5 g of P_2O_5. The solution was kept at 80 ^oC for 4.5 h, followed by thorough washing with water. Thereafter, the as-treated graphite was put into a 250 mL beaker, to which 0.5 g of $NaNO_3$ and 23 mL of H_2SO_4 (98%) were then added while keeping the beaker in the ice bath. Subsequently, 3 g of $KMnO_4$ was added slowly. After 5 min, the ice bath was removed and the solution was heated up to and kept at 35 ^oC under vigorous stirring for 2 h, followed by the slow addition of 46 mL of water. Finally, 40 mL of water and 5mL of H_2O_2 was added, followed by water washing and filtration. The exfoliation of graphene oxide was then dispersed in water (5 mg mL^{-1}) under ultrasonication for 2 h to yield a homogeneous suspension.

Synthesis of Fe_3O_4/RGO:

The whole synthetic process was taken under the protection of Ar. Typically, 155 mg $FeCl_3$ and 57 mg $FeCl_2$ were dissolved in 40 mL H_2O followed by added in 5 mL GO aqueous solution. Five minutes later, 0.5 mL NH_3H_2O was dropped into the mixture slowly. The solution was heated in an oil bath at 80 ^oC for one hour. After cooling down to room temperature naturally, the as-obtained products were collected directly by the help of a magnet.

Synthesis of CdS/Fe_3O_4/RGO:

0.6 mmol $CdCl_2$, 0.8 mmol Na_3Cit and 1.2 mmol thiourea were dissolved in H_2O to form a colorless solution. Then a solution prepared by dispersing of the as-prepared Fe_3O_4/RGO in 10 mL H_2O was dropped in. Ammonia (28 wt% in water) was used to adjust the pH to around 12. Finally, the mixture was heated in an oil bath at 70 ^oC for two hours.

Synthesis of Au/CdS/Fe_3O_4/RGO:

50 mg CdS/Fe_3O_4/RGO sample was dispersed in 30 mL water followed by boiling the water for 5 min. Then a mixed solution contained certain amount of $HAuCl_4$ (0.02M) and Na_3Cit with the molar ratio of 1/7 was injected into the solution. 30 min later, the reaction was stropped by removing the heating source. The products were washed with water for three times.

Characterization:

The X-ray diffraction pattern of the product was collected on a Rigaku-D/max 2500 V

X-ray diffractometer with Cu Kα radiation (λ = 1.5418 Å), with an operation voltage and current maintained at 40 kV and 40 mA. Transmission electron microscopic (TEM) images and high-resolution transmission electron microscopic (HRTEM) images were obtained using a TECNAI G2 highresolution transmission electron microscope operating at 200 kV. XPS measurement was performed on an ESCALAB-MKII 250 photoelectron spectrometer (VG Co.). X-ray radiation as the X-ray source for excitation.

Photocatalytic Measurement:

The photocatalytic performance of the as-obtained product was evaluated through the experiment of photocatalytic degradation of dyes under visible light irradiation. Typically, 20 mg sample was dispersed into 100 ml Methylene Green (MG) aqueous solution (0.01 mg/mL). The mixed suspensions were continuously stirred for 0.5 h in the dark to reach an adsorption-desorption equilibrium. Under the ambient conditions and stirring, the mixed suspensions were exposed to visible light irradiation produced by a 400 W metal halogen lamp with a cut off filter ($\lambda \geqslant 420$ nm). At certain time intervals, 2 ml of the mixed suspensions were extracted and centrifuged to remove the photocatalyst. The degradation process was monitored by measuring the absorption of MG in the filtrate at 652 nm using a UV-vis absorption spectrometer.

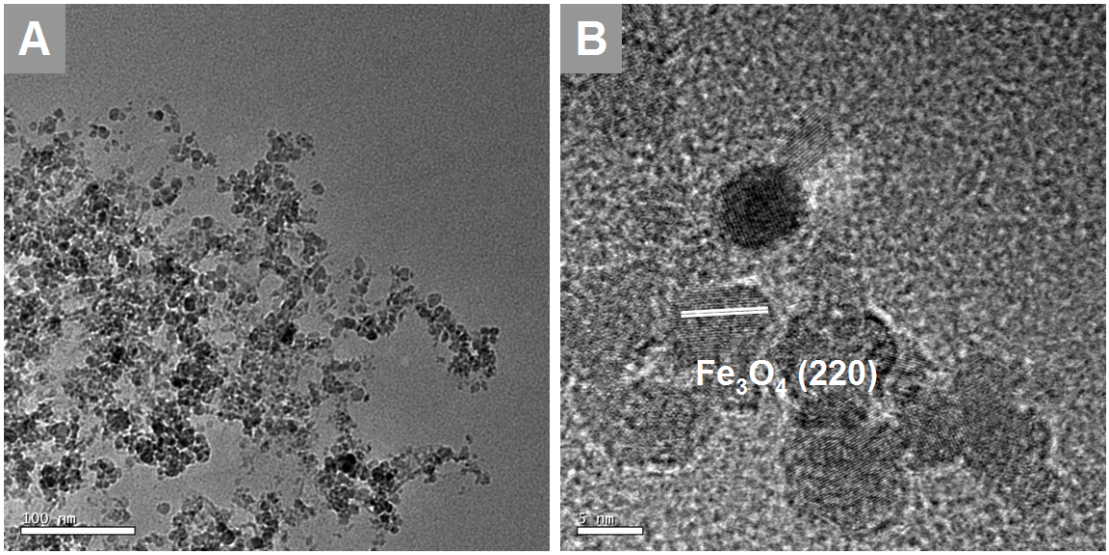

Fig. S1. TEM images of Fe_3O_4/RGO sample.

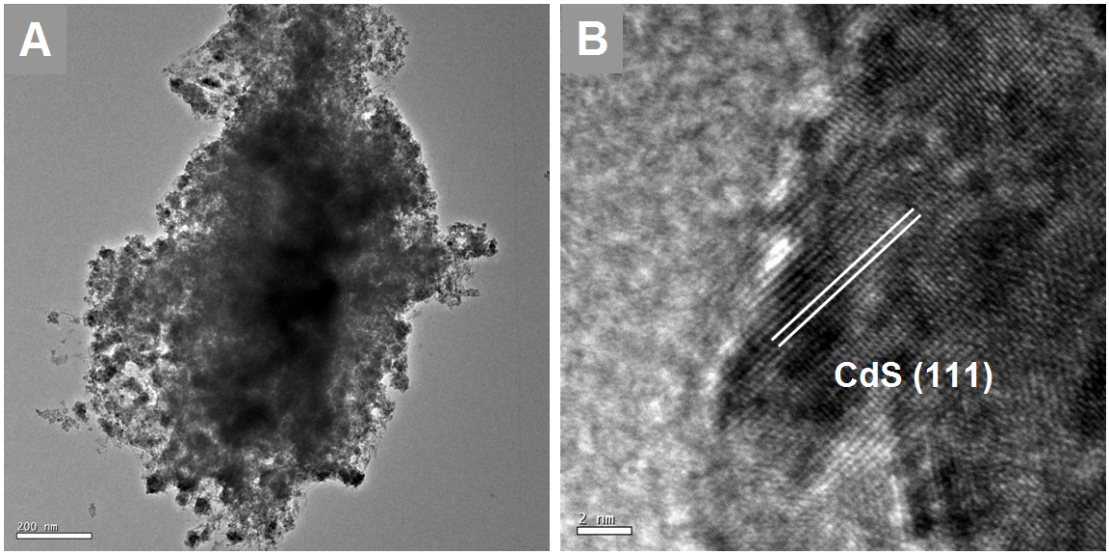

Fig. S2. TEM images of CdS/Fe_3O_4/RGO sample.

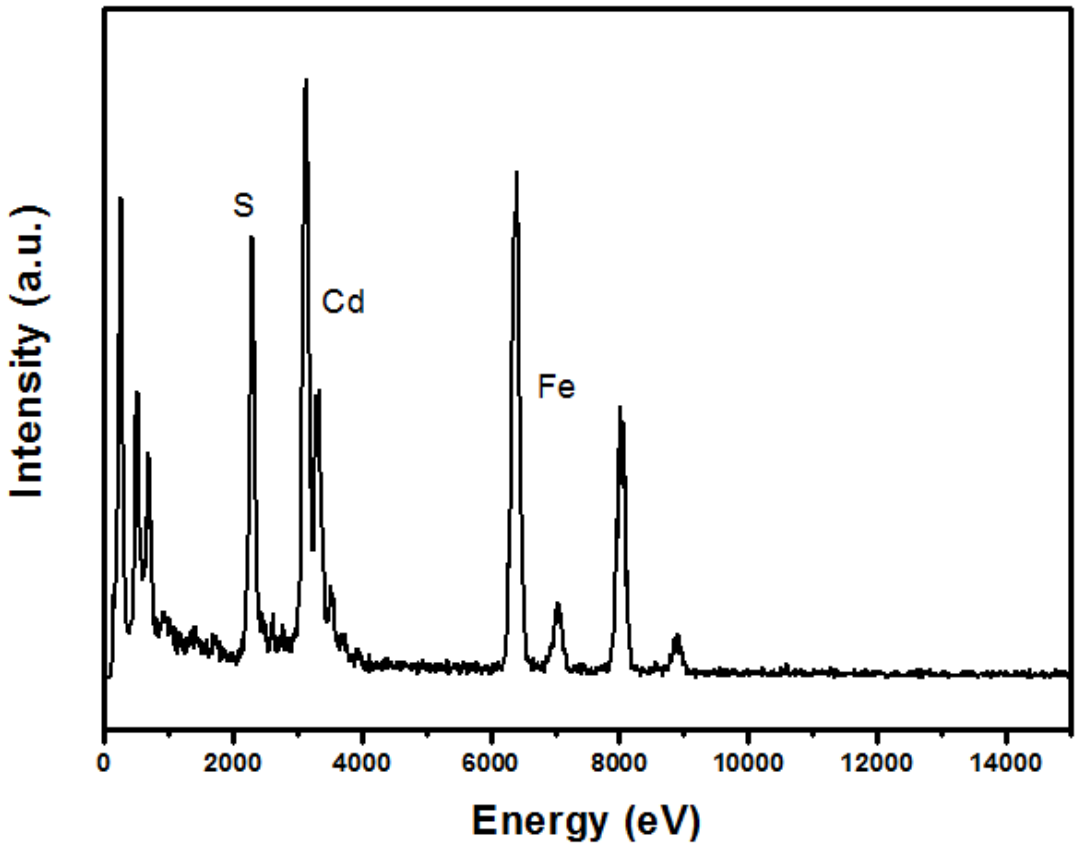

Fig. S3. EDX spectrum of CdS/Fe_3O_4/RGO sample.

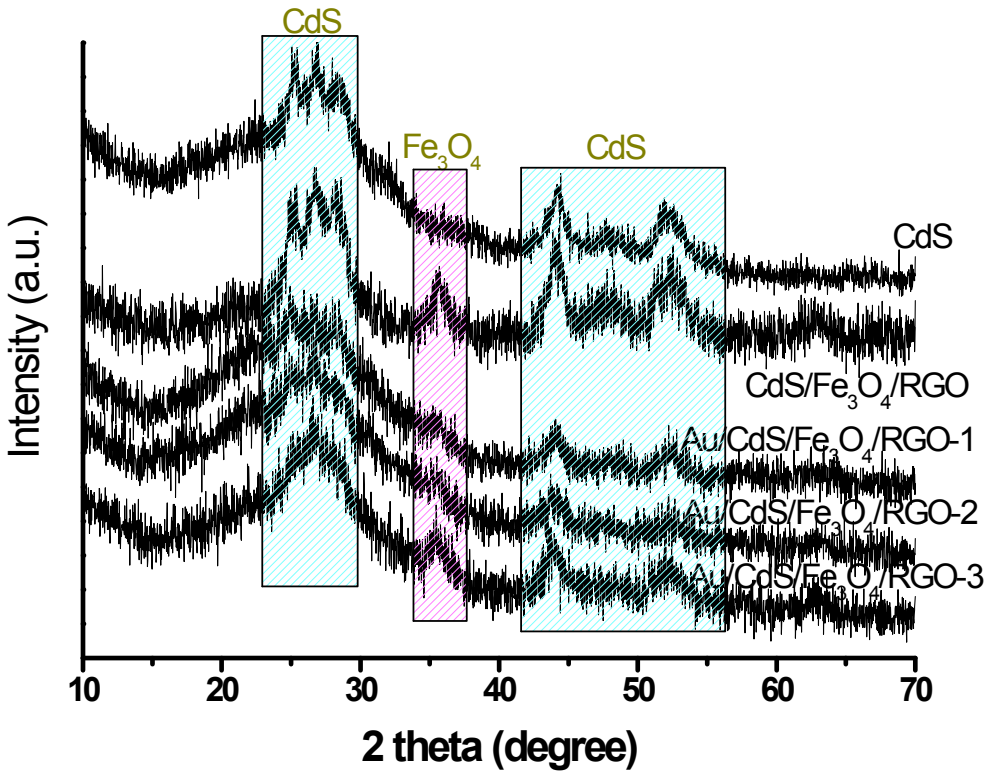

Fig. S4. XRD data of pure CdS, $CdS/Fe_3O_4/RGO$, $Au/CdS/Fe_3O_4/RGO$-1, $Au/CdS/Fe_3O_4/RGO$-2, $Au/CdS/Fe_3O_4/RGO$-3.

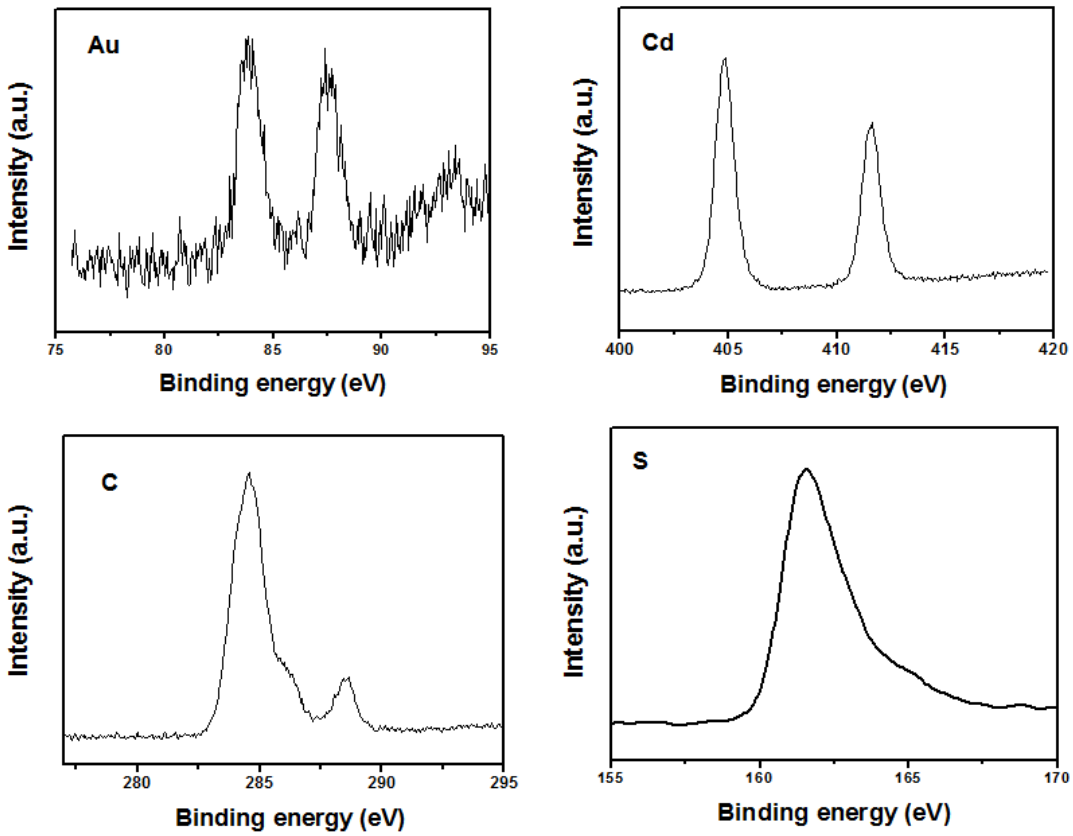

Fig. S5. XPS spectra of Au, Cd, C and S in Au/CdS/Fe_3O_4/RGO-1 sample.

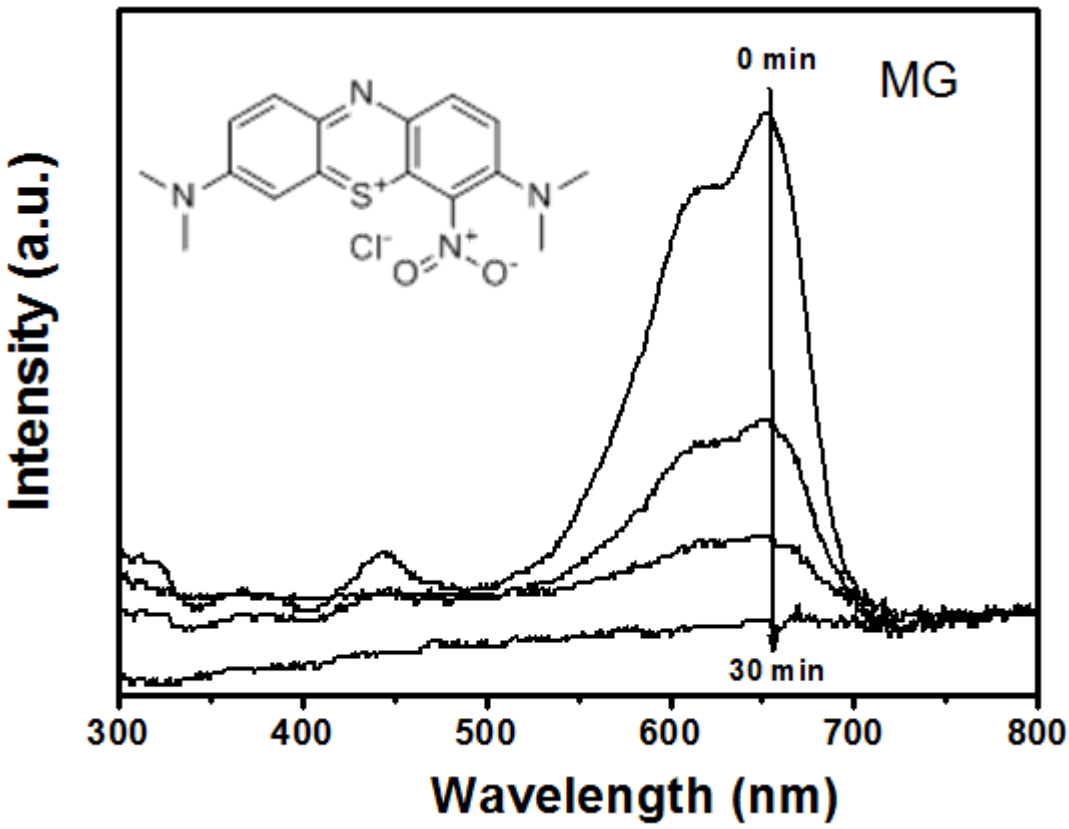

Fig. S6. Time-online Photocatalytic degradation of MG by Au/CdS/Fe_3O_4/RGO-1.

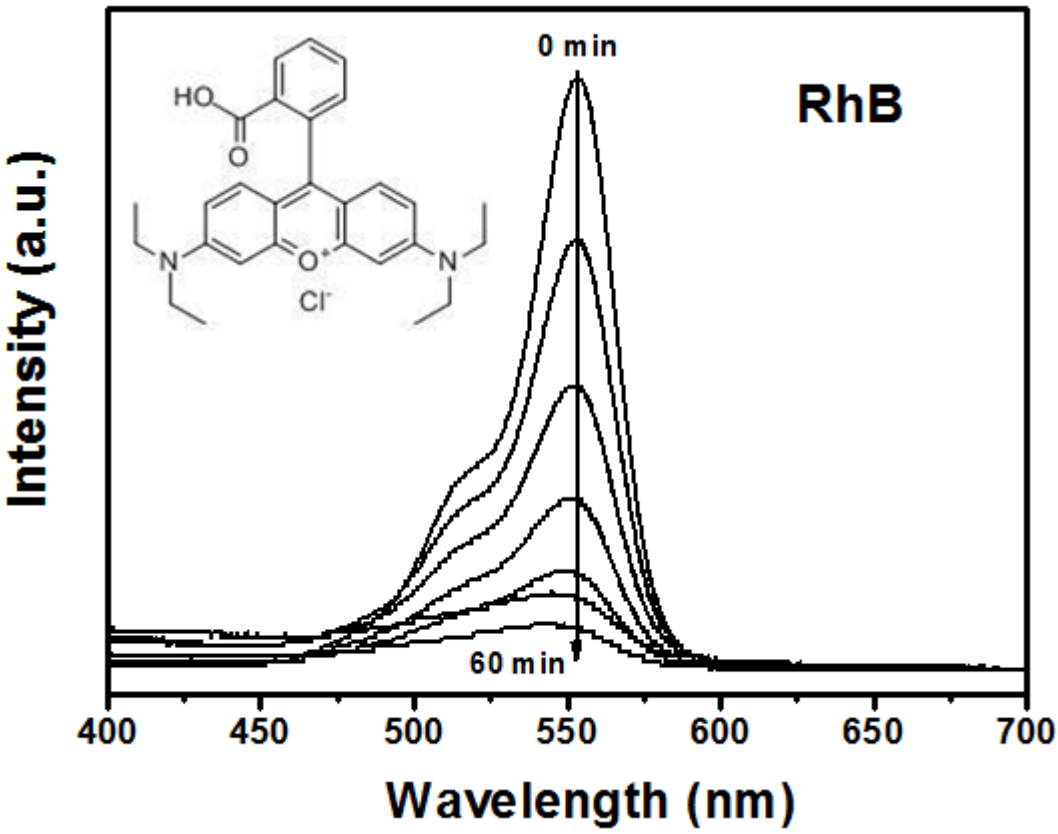

Fig. S7. Time-online Photocatalytic degradation of RhB by Au/CdS/Fe_3O_4/RGO-1.

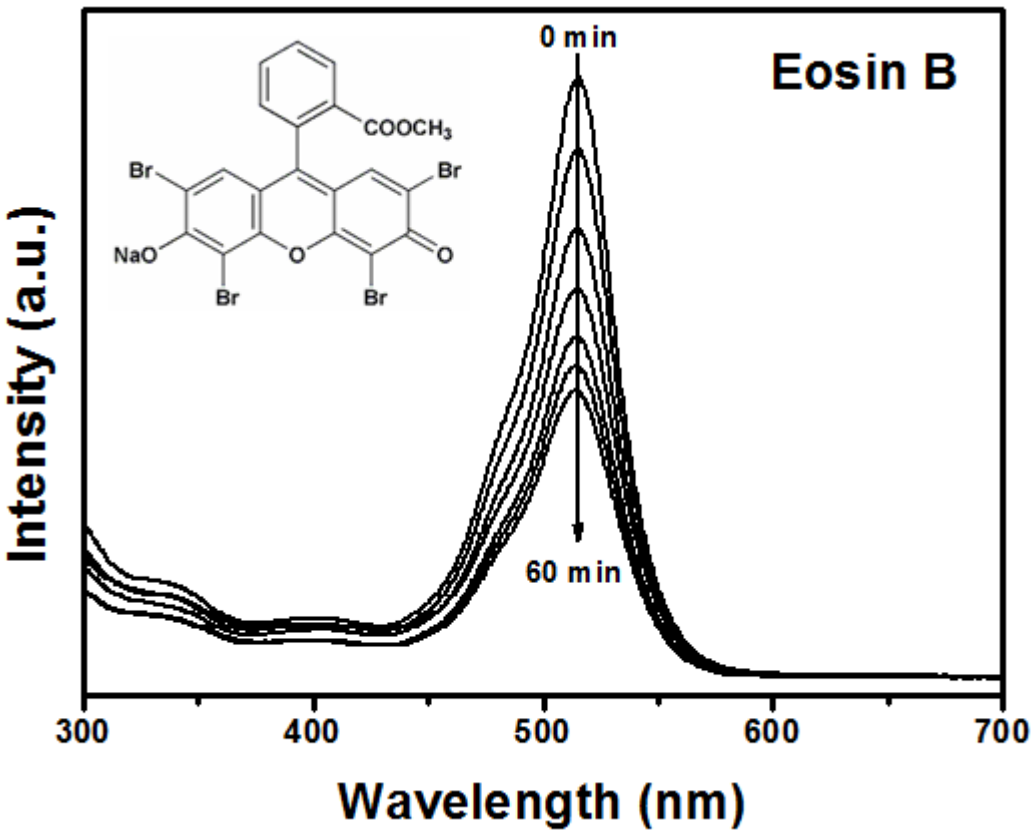

Fig. S8. Time-online Photocatalytic degradation of Eosin B by Au/CdS/Fe_3O_4/RGO-1.

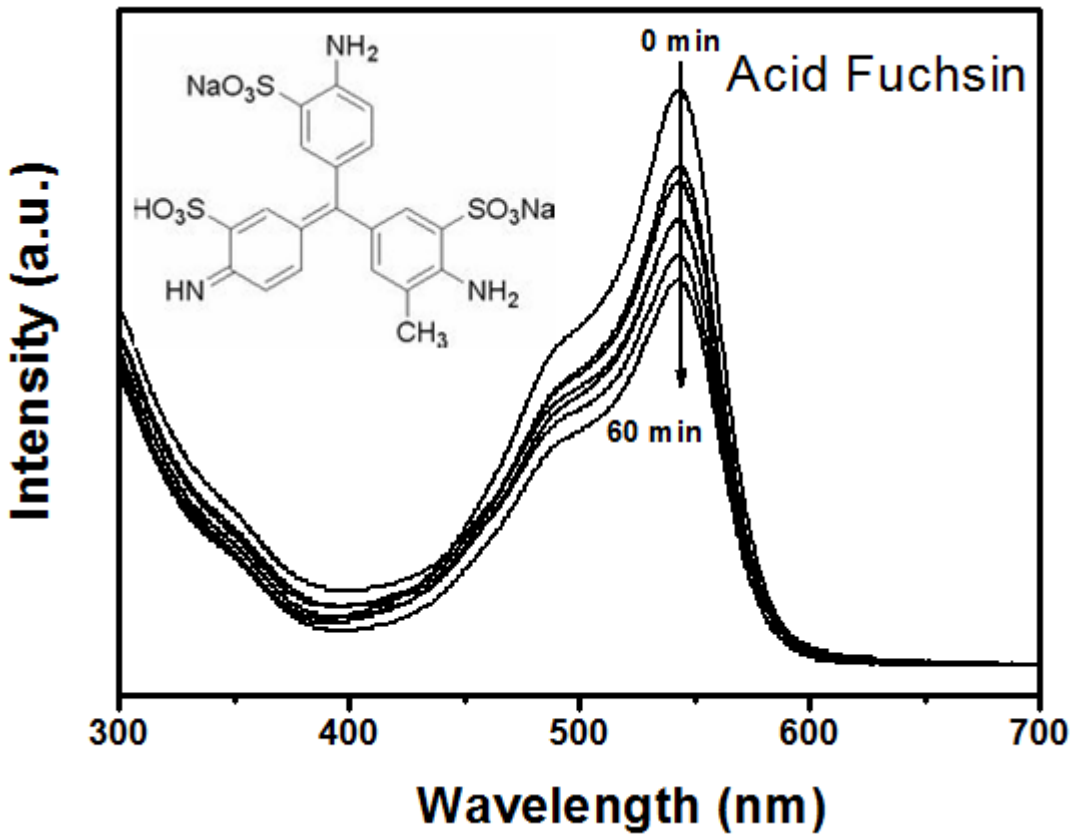

Fig. S9. Time-online Photocatalytic degradation of Acid Fuchsin by Au/CdS/Fe_3O_4/RGO-1.

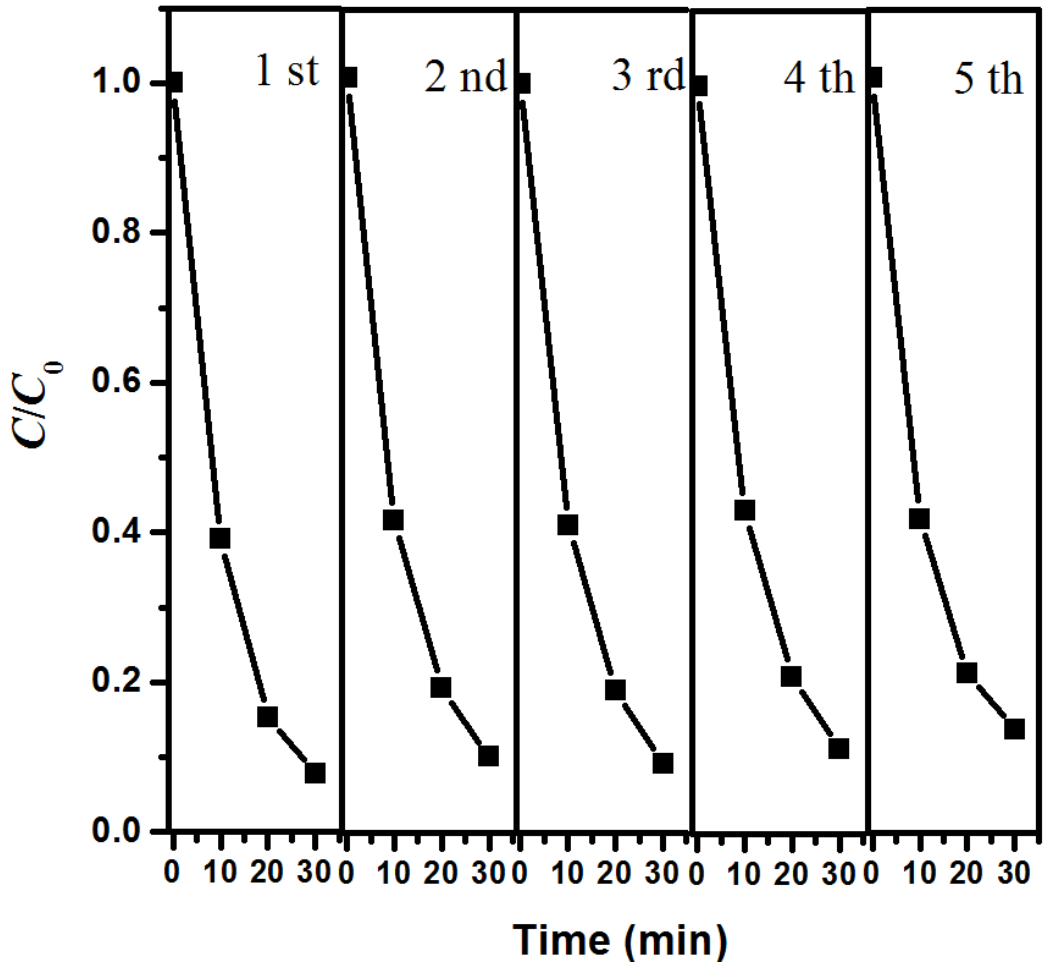

Fig. S10. cycling test of Au/CdS/Fe_3O_4/RGO-1.