Electronic Supplementary Information (ESI)

Starfish-like Au-CdS hybrids for high efficient photocatalytic degradation of organic dyes

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1. Experiment Details

Materials

Cadmium chloride ($CdCl_2$) was purchased from Sigma-Aldrich; aminophenol ($NH_2CH_2CH_2OH$) (AE) was purchased from Acros Chemicals; sodium sulfide (Na_2S) was purchased from Aladdin; and Au nanoparticles ($9*10^{10}$ units/mL) with a size of 40nm was purchased from British Biocell International. Quartz plates (2.5 cm * 2.5 cm) with high light transmittance were obtained from Jinghe Optical Instruments. Polycarbonate (PC) membrane (Whatman) with a mean pore size of 200 nm and diameter of 2 cm was used here. Deionized water (18.2 MΩ) was obtained from Millipore Direct-Q system.

Preparation of Au-$Cd(OH)_2$ SFs

$Cd(OH)_2$ nanowires were synthesized by the method developed previously.[1] Briefly, 25 mL AE (0.8 mM) aqueous solution were mixed with 25 mL $CdCl_2$ aqueous solution under stirring for about 30 minutes. Then the $Cd(OH)_2$ nanowires are formed in the aqueous solution. Au NPs colloids with uniform size were dropped into the $Cd(OH)_2$ NWs quickly with stirring. The assembling between Au NPs and $Cd(OH)_2$ NWs would complete within 20 seconds. Three samples with the volume proportion of $Cd(OH)_2$ NWs and Au NPs, 2:1, 5:1, 10:1, were prepared respectively.

Preparation of Au-CdS SFs

H_2S was used to convert Au-$Cd(OH)_2$ SFs into Au-CdS SFs. Au-$Cd(OH)_2$ hybrids were put into an atmosphere of H_2S for 2 hours. The H_2S was generated from Na_2S aqueous solution by

adding diluted HCl. And the whole process is manipulated in a glove box to avoid CO_2. The preparation method of CdS was same as that of CdS-Au SFs. All the experiments were carried out at room temperature. The content Au in this sample is about 0.4% calculated from the precursors 0.15 mM $CdOH)_2$ in $Cd(OH)_2$ NWs solution and 0.9 x 10^{11} units/mL 40 nm Au colloids with volume ratio of 2:1.

Characterization

The phases of the samples were characterized by X-ray diffraction (PANalytical, Netherlands). The morphologies and structures of the hybrids were featured by SEM (Hitachi S-4800) and TEM (Philips CM200).The optical absorption of samples was characterized by a Shimadzu UV-3600 spectroscope. To study the optical absorption of as-prepared film, we transferred the film from PC membrane to a quartz plate. The PL measurements and decay time of the as-synthesized Au-CdS SFs and CdS NWs were carried out on a FLS 920 fluorescence spectrometer. The excitation light wavelength of PL measurement was 325 nm, aroused by xenon lamp. Decay times were measured by a laser at the excitation light wavelength of 450 nm.

Photocatalytic performance

Photocatalytic performances were analyzed by degredating RhB. 1.5 mg CdS NWs (or Au-CdS SFs) was added into 20 mL RhB (10 mM) solution. To obtain the equilibrium of adsorption and desorption, the RhB aqueous solution with as-prepared films should be placed in the dark for 1 hour. Afterwards the xenon lamp (350 W) which was filtered by a 420 nm filter was used to initiate the photocatalytic reaction. Every 30 minutes, 3 mL of RhB aqueous solution was taken out for UV-Vis absorption test. After that, solution was returned back to the photocatalytic system. Similarly, the photocatalytic measurement of Au NPs was carried out under the same conditions.

2. SEM of as-prepared hybrids

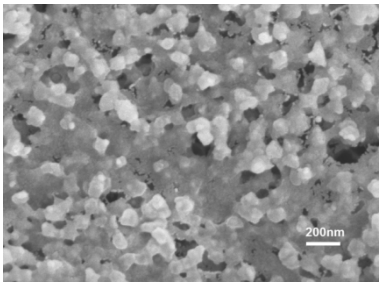

Fig. S1 SEM images of Au-CdS transferred by immersing Na_2S solution.

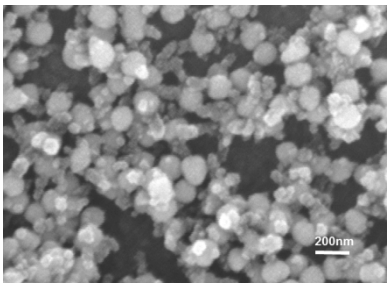

Fig. S2 SEM images of Au-$Cd(OH)_2$ at the volume ratio of 2:1.

3. **UV-visible absorption spectrum**

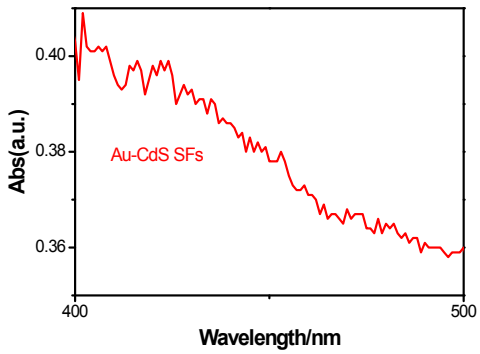

Fig. S3 The enlarged figure of UV-visible absorption spectra of Au-CdS SFs from 400 nm to 500 nm.

4. Photodegradation of RhB

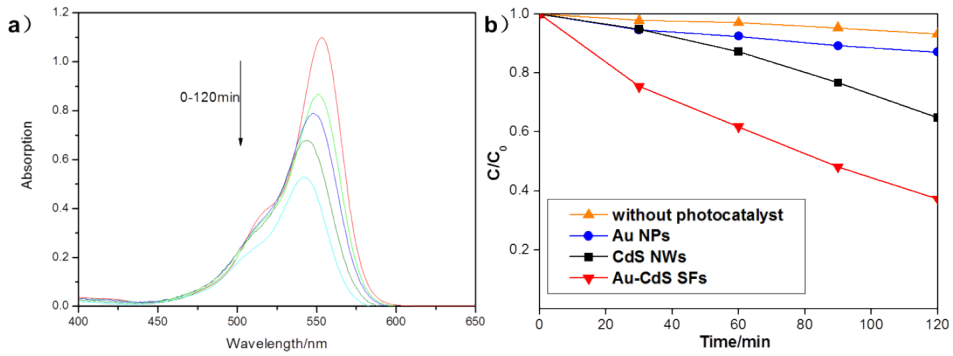

Fig. S4 (a) UV-visible absorption spectral observed for RhB solution in the presence of Au-CdS SFs. (b) Photodegradation of RhB dye under visible-light in presence of Au NPs, CdS NWs, Au-CdS SFs and without photocatalyst.

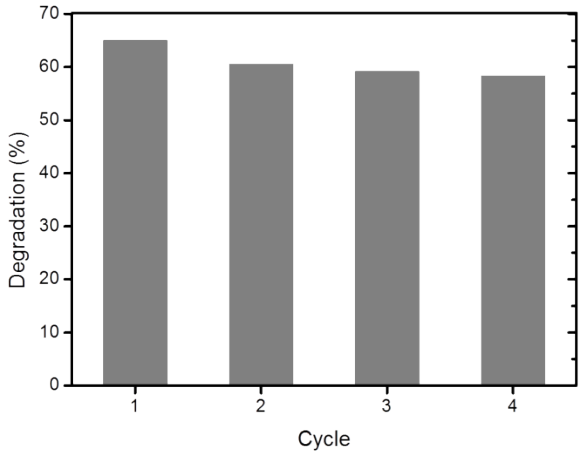

Fig. S5 Degradation (%) of RhB after recycling with Au-CdS SFs under visible light for 2 hours.

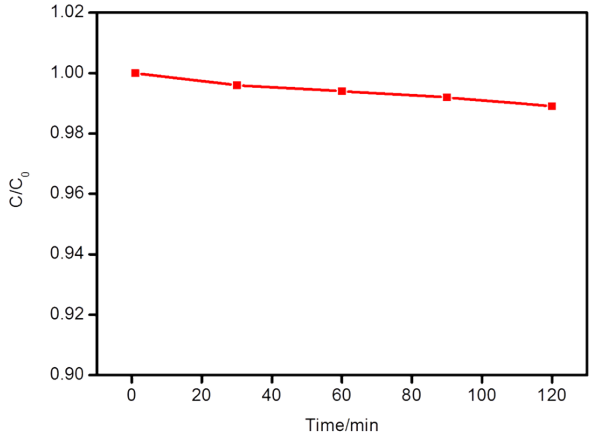

Fig. S6 The concentration change of RhB with Au-CdS SFs in dark room for 2 hours.

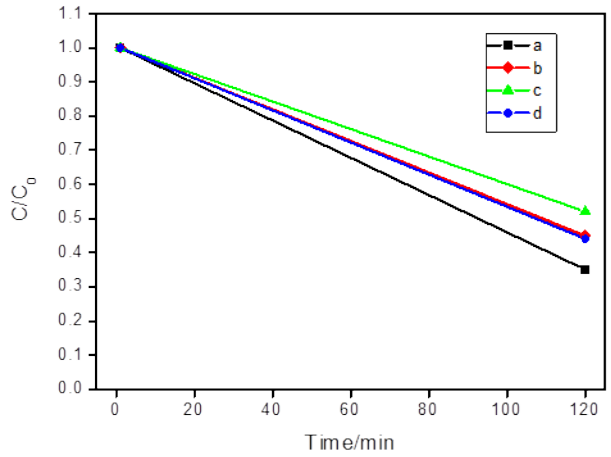

Fig. S7 The photodegradation of Au/CdS hybrids prepared from different volume ratios of 40 nm Au colloids and $Cd(OH)_2$ nanowires: (a) 1:2, (b) 2:1, (c) 1:10, (d) 1:5, for RhB

Reference

1 I. Ichinose, K. Kurashima, T. Kunitake, *J. Am. Chem. Soc.*, 2004, **126**, 7162.