Controllable fabrication of immobilized ternary CdS/Pt-TiO$_2$ heteronanostructures toward high-performance visible-light driven photocatalysis

Honge Wang$^a$, Jun Lv$^a$, Huazhen Gao$^a$, Guangqing Xu$^a$, Dongmei Wang$^a$, Xinyi Zhang$^b$, Zhong Chen$^c$, Zhixiang Zheng$^a$, Yucheng Wu$^{a,d}$

$^a$School of Materials Science and Engineering, Hefei University of Technology, Hefei, 230009, China; E-mail: lvjun@hfut.edu.cn  ycwu@hfut.edu.cn

$^b$School of Chemistry, Monash University, Clayton, VIC 3800, Australia

$^c$School of Materials Science and Engineering, Nanyang Technological University, Singapore

$^d$Key Laboratory of Advanced Functional Materials and Devices of Anhui Province, Hefei, 230009, China
Synthetic procedure and Photocatalytic activity test of CdS/Pt/TiO₂ NTAs

Preparation of TiO₂ nanotube arrays

The anodization process was performed in a two-electrode electrochemical cell with Ti foils as the anode and a piece of highly pure graphite as the cathode. The Ti foils were anodized at 60 V for 10 h in the electrolyte containing NH₄F (0.1 M), ethylene glycol and water (10 vol%). After anodization, the obtained samples were ultrasonically cleaned in ethylene glycol for 90 s to remove the debris and other impurities, then dried in air. Finally, the samples were annealed in air at 500°C for 2 h.

Deposition of Pt, CdS NPs

Pt/TiO₂ NTAs were prepared by photoreduction deposition method. First, TiO₂ NTAs were immersed in a 14 ml aqueous solution for 2 h which contained 7 ml methanol and H₂PtCl₆·6H₂O with different concentrations. Then the samples were bubbled in nitrogen for 30 min to remove the dissolved oxygen. After that, the samples were illuminated by a 500 W Mercury lamp for 30 min at room temperature. Finally, the samples were rinsed with deionized water and dried in oven at 40°C for 2 h.

CdS/TiO₂ NTAs and CdS/Pt/TiO₂ NTAs were prepared by chemical bath deposition method (CBD). First, TiO₂ NTAs were immersed in a 0.02 M cadmium chloride aqueous solution for 30 s, rinsed with deionized water for 60 s and then in a 0.02 M sodium sulfide aqueous solution for 30 s, followed with additional rinse in deionized water for 60 s. The two-step immersing procedure was termed as one CBD cycle. This deposition cycle was repeated for 13 times. Finally, the modified samples were dried in an oven at 40°C for 2 h and then were annealed at 350°C for 2 h in Argon atmosphere with the heating rate of 1°C·min⁻¹.

Photocatalytic activity test

The photocatalytic activities of as-prepared samples under visible light were tested by an XPA-7 photochemical reactor (Nanjing Xujiang Machine-electronic Plant, China). Methyl Orange (MO) aqueous solution was used as a model pollutant to be degraded. A 250 W metal halide lamp with a UV cut-off filter was used as the resource of visible light (λ>420 nm), the photoreactor was cooled by circulating water during the photodegradation process. The volume of MO aqueous solution was 12 ml with the concentration of 10 mg/L, and the size of sample was 1.5×3 cm.
Fig. S1. Schematics of the fabrication process of CdS/Pt/TiO$_2$ NTAs

Fig. S2. Schematic diagram of XPA-7 photochemical reactor
Fig. S3. FESEM morphologies of CdS/Pt/TiO2 NTAs prepared with different H2PtCl6 concentrations (a,b 1 mmol·L⁻¹; c,d 2 mmol·L⁻¹; e,f 3 mmol·L⁻¹), 13 deposition cycles of CdS
Fig. S4. FESEM morphology of Pt/TiO$_2$ NTAs prepared with 1 mmol·L$^{-1}$H$_2$PtCl$_6$

Fig. S5. FESEM morphologies of CdS/Pt/TiO$_2$ NTAs (CdS deposition cycle: 13 cycles; the concentration of H$_2$PtCl$_6$: 1 mmol·L$^{-1}$)
Fig. S6. FESEM morphologies of CdS/Pt/TiO$_2$ NTAs (CdS deposition cycle: 13 cycles; the concentration of H$_2$PtCl$_6$: 4 mmol·L$^{-1}$)

Fig. S7. FESEM morphologies of CdS/Pt/TiO$_2$ NTAs (CdS deposition cycle: 13 cycles; the concentration of H$_2$PtCl$_6$: 1 mmol·L$^{-1}$) after being reused for different times (a: 5 times; b: 10 times; c: 15 times; d: 20 times).