Supporting Information

Few-layered MoS$_2$ Nanosheets Wrapped Ultrafine TiO$_2$

Nanobelts with Enhanced Photocatalytic Property

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Figure S1 Morphology of ultrafine TiO$_2$ nanobelts and MoS$_2$/TiO$_2$ nanobelt heterostructures: (a) TEM image of ultrafine TiO$_2$ nanobelts, (b) (c) and (d) TEM and HRTEM images of MoS$_2$/TiO$_2$ nanobelt heterostructures (5% of MoS$_2$).

Figure S1 (a) shows the morphology of ultrathin TiO$_2$ nanostructures with DMF/HAc to be 6/4 (v/v). It is observed that the ultrafine TiO$_2$ nanostructures are very flexible and they are confirmed to be ultrathin with no more than 5 nm in thickness and 10-20 nm in width and hundreds nm in length.
TEM and HRTEM images of MoS$_2$/TiO$_2$ nanobelt heterostructures are shown in Figure S1 (b), (c) and (d). The thickness of the MoS$_2$ sheets is measured as about 1.4 nm or 2.2 nm, indicating that the some nanosheets are multilayer MoS$_2$ nanosheets$^{1-4}$. 

![TEM images of MoS$_2$/TiO$_2$ hybrid nanobelt with different MoS$_2$ loading amount: (a) 2%, (b) 5 % (c) 10% and (d) 50%](image)

Figure S2. TEM images of MoS$_2$/TiO$_2$ hybrid nanobelt with different MoS$_2$ loading amount: (a) 2%, (b) 5 % (c) 10% and (d) 50%. As shown in Figure S2a, layered MoS$_2$ nanosheets partly wrapped on the surface of ultrafine TiO$_2$ nanobelts is present. With MoS$_2$ loading amount increase to 5%, layered crystal structure fully wrapped on the surface of ultrafine TiO$_2$ nanobelts is present (Figure S2b). So the fully wrapped MoS$_2$/TiO$_2$ hybrid nanobelts are selected, which possess the highest photocatalytic performance (see Figure S4). When MoS$_2$ loading amount increases to 10% and 50%,
overmuch MoS$_2$ naonosheet or multilayered MoS$_2$ grown on the naonobelts (Figure S2c
and S2d). Which weaken their photocatalytic performance.

**S2 EDS results from MoS$_2$/TiO$_2$ nanobelt heterostructures**

![Energy dispersive X-ray spectrometry (EDS) results of an MoS$_2$/TiO$_2$ nanobelt heterostructures with individual elements of Mo, S, Ti and O (Figure S3).](image)

Figure S3 EDS results from MoS$_2$/TiO$_2$ nanobelt heterostructures (5% of MoS$_2$).

Energy dispersive X-ray spectrometry (EDS) results of an MoS$_2$/TiO$_2$ nanobelt heterostructures with individual elements of Mo, S, Ti and O (Figure S3) further confirm that the hybrid hierarchical structure where the outer layer is MoS$_2$ nanosheets and the inter layer is TiO$_2$ nanobelt.

**S3 Degradation of MO for MoS$_2$/TiO$_2$ nanobelt heterostructures**
Figure S4. Comparisons of photocatalytic activities among the MoS$_2$/TiO$_2$ samples with different weight ratios with different MoS$_2$ loading amount: (a) 2%, (b) 5 % (c) 10% and (d) 50% under UV light irradiation in 15 min.

As shown in Figure 6a in the main text, in the presence of pure TiO$_2$ nanobelt, about 92.4% of MO is degraded within 15 min, while the degradation ratio is of 100% in the presence of the MoS$_2$/TiO$_2$ hybrid nanobelts. For MoS$_2$/TiO$_2$ hybrid nanobelts with increasing MoS$_2$ loading amount of MoS$_2$, the photocatalytic performance decreases and the optimized MoS$_2$ loading amount is 5% (Figure S4). This is attributed to layered MoS$_2$ nanosheets fully wrapped on the surface of ultrafine TiO$_2$ nanobelts.
Figure S5 Absorption spectra of MO solution during the photocatalytic degradation under (a) UV and (b) visible light irradiation treatment in presence of MoS$_2$/TiO$_2$ nanobelt heterostructures.

Figure S5 shows the absorption spectra of methylene orange (MO) solution during the photocatalytic degradation under (a) UV and (b) visible light irradiation treatment in presence of MoS$_2$/TiO$_2$ nanobelt heterostructures. From Figure S5, it can be observed that the photocatalytic degradation rate can reach 100% under either (a) UV or (b) visible light irradiation.
Figure S6 Photocatalytic degradation of MO by the MoS$_2$/TiO$_2$ nanobelt heterostructures in repeated experiments under (a) UV and (b) visible light irradiation.

To examine the photocatalytic stability of the catalysts, the efficiency of the MO photodegradation was evaluated in a repetitive mode using the same photocatalysts. As shown in Figure S6 a and b, the MO dye was quickly decomposed after every injection of the MO solution and the MoS$_2$/TiO$_2$ nanobelt heterostructures are stable under repeated experiments with a nearly constant photodecomposition rate. Thus, the MoS$_2$/TiO$_2$ nanobelt heterostructures are an effective and stable photocatalyst under UV and visible light irradiation.

**S4 Photocatalytic H$_2$ evolution from an aqueous methanol solution**

![Graph showing photocatalytic hydrogen evolution activities](image)

Figure S7 Comparison of the photocatalytic hydrogen evolution activities of different samples.

For comparison, the photocatalytic activities of pure P25, ultrafine TiO$_2$ nanobelts and MoS$_2$ are also displayed. To check the intrinsic photocatalytic property of the samples,
noble nanoparticles were not sputtered on the samples before hydrogen generation measurement. Figure S7 illustrates the hydrogen evolution from an aqueous solution containing methanol as sacrificial agents. Under irradiation of simulated light, the hydrogen generation rate of the MoS$_2$/TiO$_2$ nanobelt heterostructures is about 75 $\mu$mol$\cdot$h$^{-1}\cdot$g$^{-1}$, while the hydrogen generation rate of the P25, TiO$_2$ nanobelts and MoS$_2$ nanosheets is about 29 $\mu$mol$\cdot$h$^{-1}\cdot$g$^{-1}$, 21 $\mu$mol$\cdot$h$^{-1}\cdot$g$^{-1}$, and 19 $\mu$mol$\cdot$h$^{-1}\cdot$g$^{-1}$, respectively.

Figure S8 Photocatalytic H$_2$ evolution in 8 h repeated cycles by the MoS$_2$/TiO$_2$ nanobelt heterostructures.

Repetitive photocatalytic H$_2$ evolution from an aqueous methanol solution for the MoS$_2$/TiO$_2$ nanobelt heterostructures is shown in the Figure S8. After four cycles of 8 h reaction, the MoS$_2$/TiO$_2$ nanobelt heterostructures still retained high photocatalytic activity, which demonstrates their stability.

S5 Schematic illustration of photo-induced charge transfer and separation
A tentative mechanism proposed for the H₂ production and pollutant degradation based on the occurrence of vectorial electrons and holes transfer in MoS₂/TiO₂ hybrid nanobelt was shown in Figure S9. Under light irradiation, the photogenerated electrons from the valence band (VB) of MoS₂ nanoparticles are directly transferred to conduction band (CB) of MoS₂, and leaving behind holes in the VB. As the CB of TiO₂ is lower than that of MoS₂, the TiO₂ can be used as a photoelectronic acceptor, the photogenerated electrons of the MoS₂ CB will be transferred to the CB of TiO₂ nanobelts. The photogenerated electrons can be trapped by oxygen molecules in the aqueous solution to form singlet oxygen. Simultaneously, the holes moved in the opposite direction from the electrons, photogenerated holes will be captured within the MoS₂ nanosheets. The photogenerated
electrons and holes can be separated effectively and improve the photocatalytic activity of MoS$_2$/TiO$_2$ nanobelt heterostructures.

Reference