Supplementary Information

1. Preparation of YF_3:Yb^{3+},Tm^{3+} nanocrystals

YF_3:Yb^{3+},Tm^{3+} nanocrystals were prepared by a modified hydrothermal method. Y_2O_3 (0.795 mmol), Yb_2O_3 (0.2 mmol), Tm_2O_3 (0.005 mmol) were dissolved in the hydrochloric acid (40%), then the solution was heated to evaporate water completely. The obtained chloride was dissolved in distilled water. PVP (0.1 g) was added as chelating agent and stabilizer, then hydrofluoric acid (40%) was added dropwise to form colloidal solution under stirring. After reacting at 130 °C for 2 h, the product was isolated by centrifugation and dried at 60 °C, then annealed at 550 °C for 2 h under nitrogen atmosphere.

2. Characterization

The morphological characterization was performed by TEM (JEM 2010F with acceleration voltage of 200 KV). The structures of samples were determined by XRD with Rigaku RU-200b powder diffractometer using a Cu K*a* radiation (λ = 1.4518 Å). The PL spectra were recorded at room temperature using a fluorescence spectrometer (Hitachi F-4500) under the excitation of 980 nm diode laser. The absorption spectra of methylene blue were measured by a Shimadzu UV-1700 UV-visible spectrophotometer. The absorption spectra of the YF_3:Yb^{3+},Tm^{3+} and the YF_3:Yb^{3+},Tm^{3+}/TiO_2 were recorded by a Shimadzu UV-3600 UV-VIS-NIR spectrophotometer.

3. Fig. S1 Schematic energy-level diagrams of Yb^{3+} and Tm^{3+} ions and the upconversion mechanism excited by 980 nm laser diode.

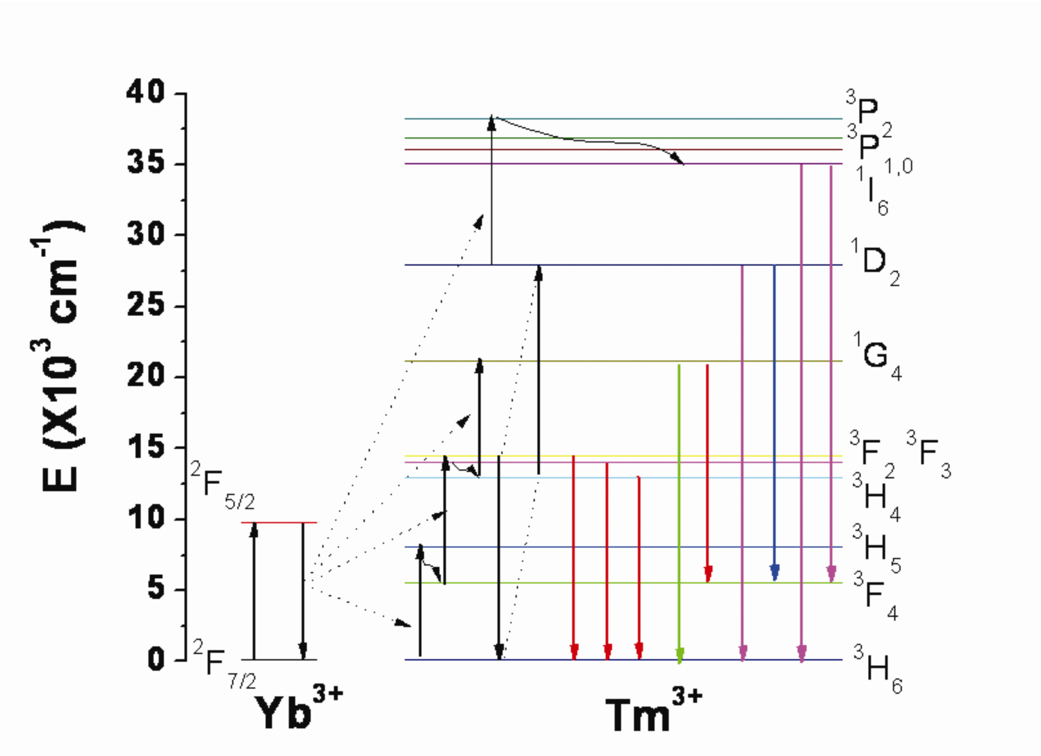

Fig. S1 Schematic energy-level diagrams of Yb^{3+} and Tm^{3+} ions and the upconversion mechanism excited by 980 nm laser diode. The solid, dotted, and curly arrows indicate radiative, non-radiative energy transfer and non-radiative relaxation processes, respectively.

4. Fig. S2 Absorption spectra of YF_3:Yb^{3+},Tm^{3+} and YF_3:Yb^{3+},Tm^{3+}/TiO_2 nanoparticles.

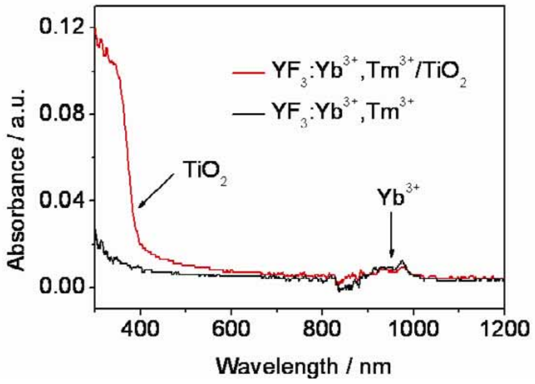

Fig. S2 Absorption spectra of YF_3:Yb^{3+},Tm^{3+} and YF_3:Yb^{3+},Tm^{3+}/TiO_2 nanoparticles.

This result indicates that the core/shell nanoparticles can absorb near infrared light around 980 nm due to the dopant of Yb^{3+} ions.

5. Photocatalytic activaty measurement under UV light irradiation

Methyl orange (MO) was used as the model pollutant for UV photocatalysis, because its stablity under UV irradiation. The UV lamp (6 W) working at 365 nm was used as the irradiation source. The YF_3:Yb^{3+},Tm^{3+}/TiO_2 nanoparticles (2 mg) were added into MO aqueous solution (20 M, 5 ml) in a beaker. After stirring in the dark for 12 h, the MO aqueous solution was irradiated by the UV light from the top of the beaker and carried out the photocatalysis with continuous stirring. The photocatalysis of the pure TiO_2 was checked by using the same method, and the absorption of MO aqueous solution without photocatalyst was also measured under UV irradiation to make a comparition.

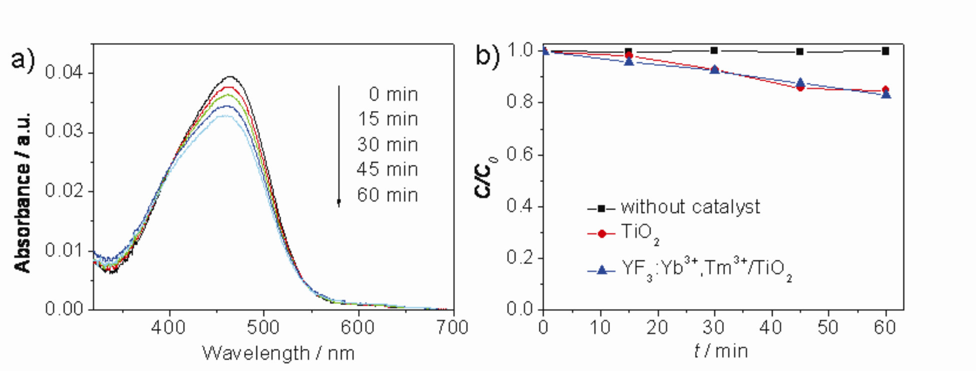

Fig. S3 a) Absorption spectra of MO catalyzed by YF_3:Yb^{3+},Tm^{3+}/TiO_2 nanoparticles under UV irradiation. b) Comparison of the normalized concentration of MB decomposed by TiO_2 and YF_3:Yb^{3+},Tm^{3+}/TiO_2 NPs under UV irradiation.

As shown in Fig. S3 a), the absorption intensity at 462 nm decreased with the time of UV irradiation. This demonstrates that $YF_3:Yb^{3+},Tm^{3+}/TiO_2$ nanoparticles can decompose the MO under the UV light. Fig. S3 b) shows the normalized concentration of MO without catalysts and with TiO_2 and $YF_3:Yb^{3+},Tm^{3+}/TiO_2$ catalysts. The concention of MO without catalysts does not change, which demonstrates that the MO is stable under UV irradiation. After the UV irradiation for 60 min, the decomposed MO was 16% and 17% for TiO_2 and $YF_3:Yb^{3+},Tm^{3+}/TiO_2$ respectively, so the photocatalytic activity of $YF_3:Yb^{3+},Tm^{3+}/TiO_2$ is almost equal to which of pure TiO_2. This demonstrates that the optical filtering effect by $YF_3:Yb^{3+}$, Tm^{3+} does not compromise the activity of $YF_3:Yb^{3+},Tm^{3+}/TiO_2$ under UV irradiation, because the TiO_2 is coated uniformly over the $YF_3:Yb^{3+},Tm^{3+}$ nanocrystals.