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The Improved Efficiency of Quantum-Dot-Sensitized Solar Cells with a Wide Spectrum and Pure Inorganic Donor-Acceptor Type Polyoxometalate as a Collaborative Cosensitizer

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Supplementary Physical and Chemical Characterizations

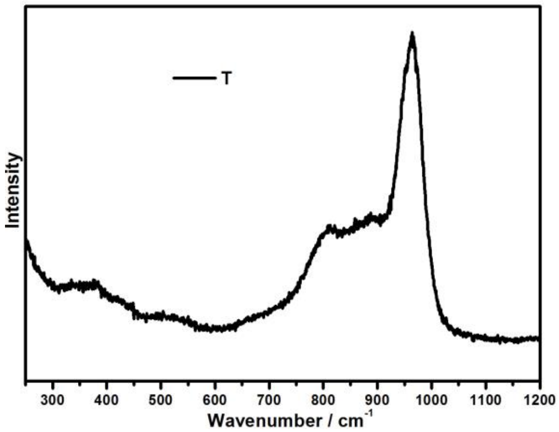

Fig. S1 The normal Raman spectrum for T.

Raman spectrum, which was studied as a kind of scattering spectrum, could provide the structure of POMs by researching their vibration and rotation energy. In the Fig. S1, the bands from 800-900 cm^{-1} were associated with the stretching mode of W-O$_b$-W or W-O$_c$-W and 900-1000 cm^{-1} were associated with the stretching mode of W-Ot. Beyond that the lower energy regions were associated with the bending mode of W-Ob-W or W-Oc-W or Si-O. Therefore the normal Raman spectrum can confirm the structure of prepared T.

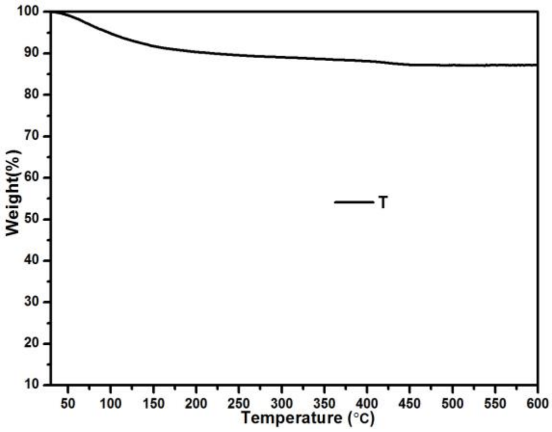

Fig. S2 TG curve of T. The thermal stability of T was analyzed by its TG curve, which displayed three-step weightlosses occurred in the temperature range of 50-600°C. The three-step weightlosses were all attributed to the loss of water.

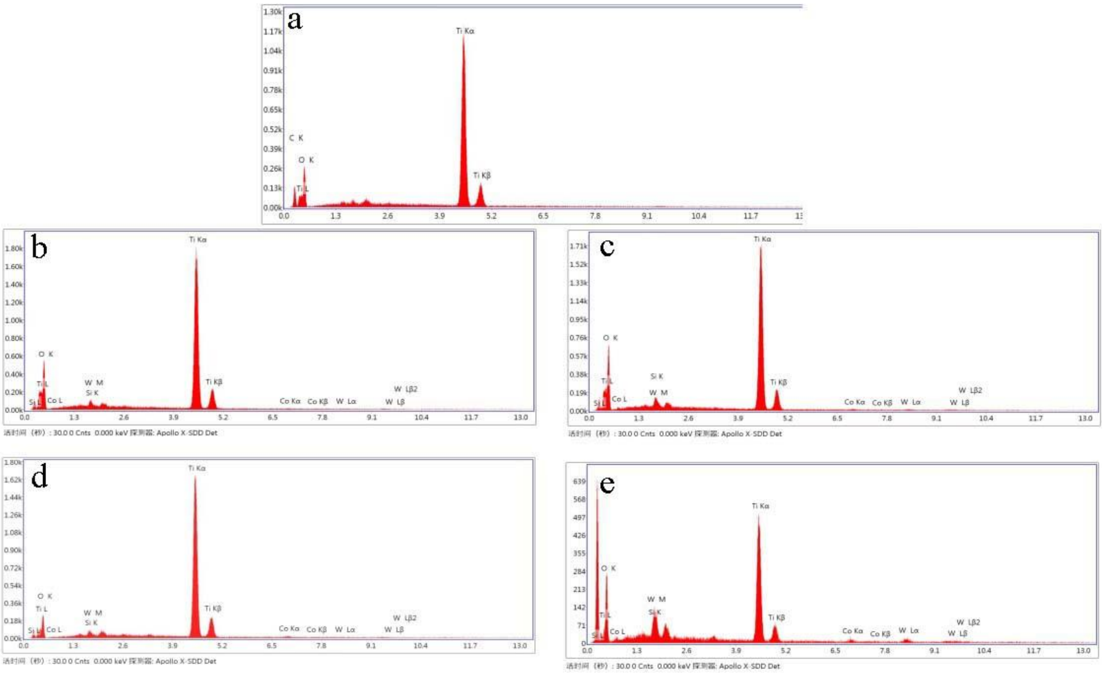

Fig. S3 EDS spectrum for a) pure TiO_2; b) T1@TiO_2; c) T2@TiO_2; d) T3@TiO_2; f) T4@$TiO_{2.}$

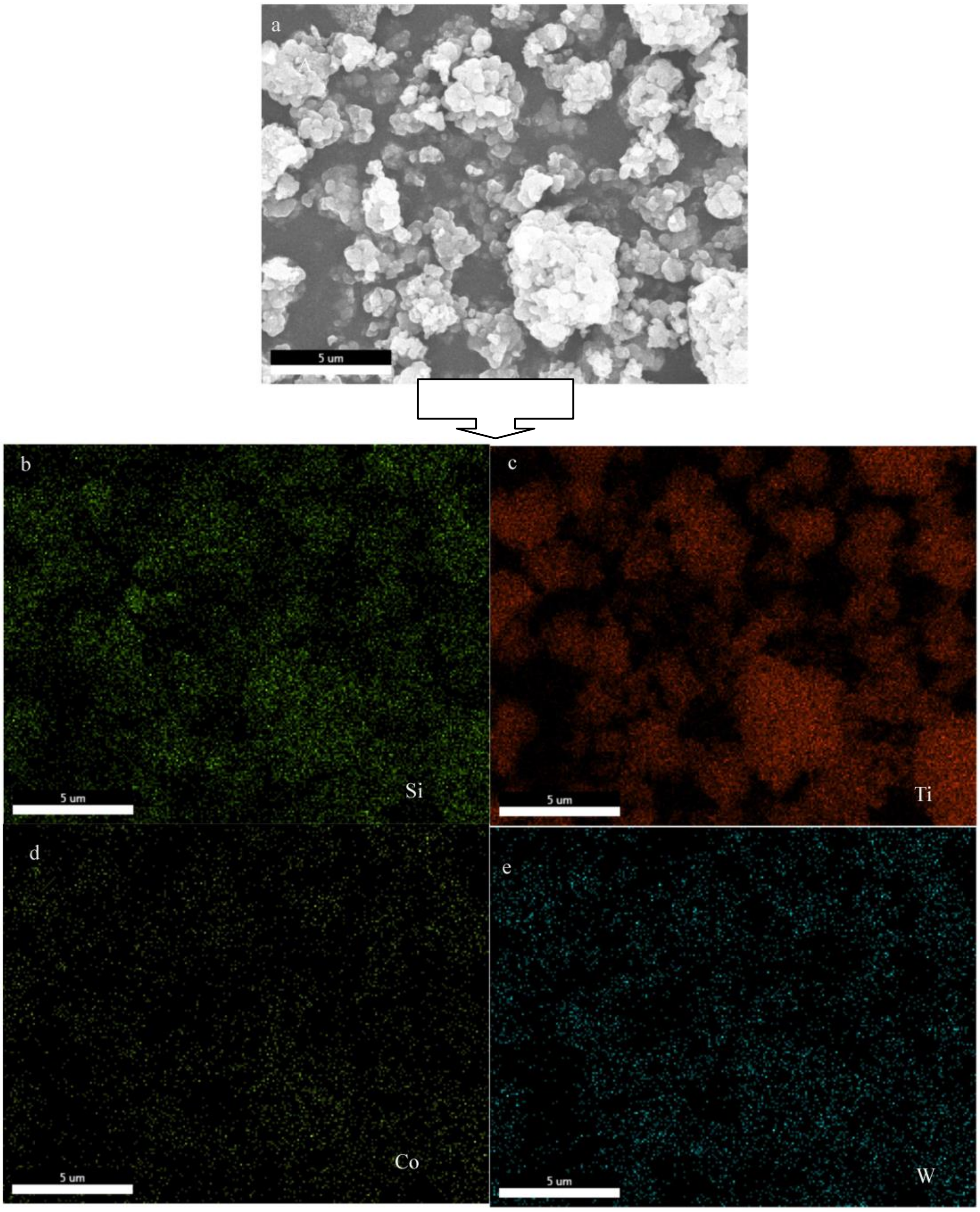

Fig. S4 Element mapping of T3@TiO$_2$ powder: a) the SEM image of the T2@TiO$_2$; b) the element mapping of Si; c) the element mapping of Ti; d) the element mapping of Co; f) the element mapping of W.

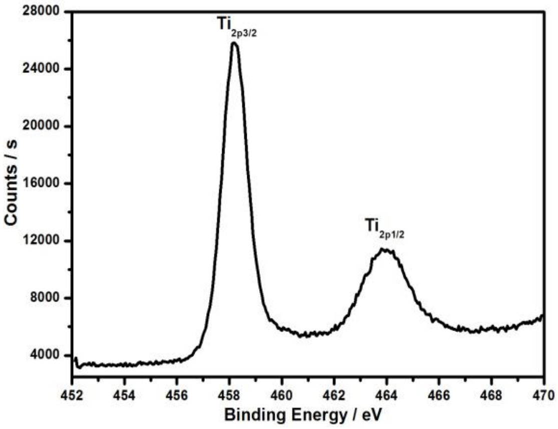

Fig. S5 The X-ray photoelectron spectroscopy of Ti of T3@TiO_2. The Fig. S5 exhibits two peaks at ca. 458.2 eV in the energy region of $Ti_{2p3/2}$ and ca. 463.9 eV in the energy region of $Ti_{2p1/2}$, which are consistent with the Ti^{IV} oxidation state.[S1]

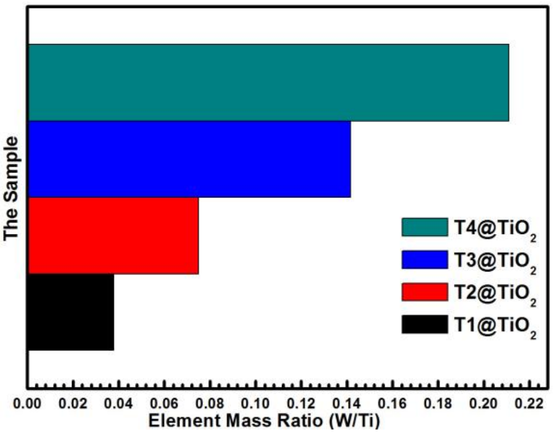

Fig. S6 The elemental mass ratio of W/Ti in T1@TiO_2, T2@TiO_2, T3@TiO_2, T4@TiO_2. The loading amount of T in the composites was determined by inductively coupled plasma atomic emission spectrometer(ICP-AES), from which the W content in composites was 3.78%, 7.49%, 14.17%, 21.10% respectively.

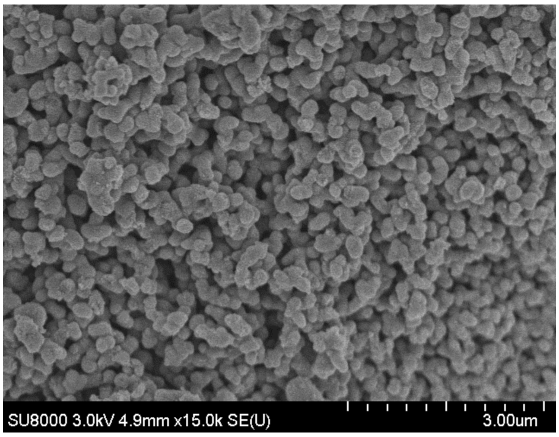

Fig. S7 The SEM images of the prepared T2@TiO_2 under the low multiples.

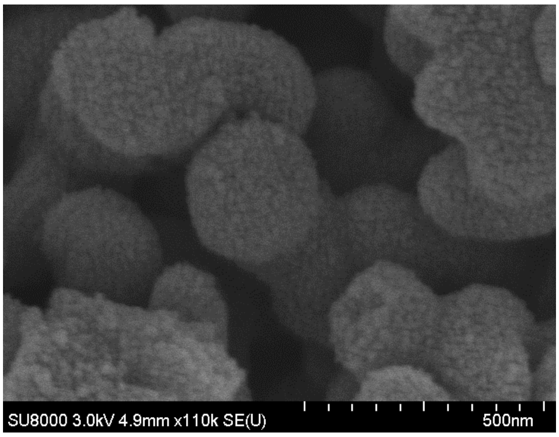

Fig. S8 The SEM images of the prepared T2@TiO_2 under the high multiples.

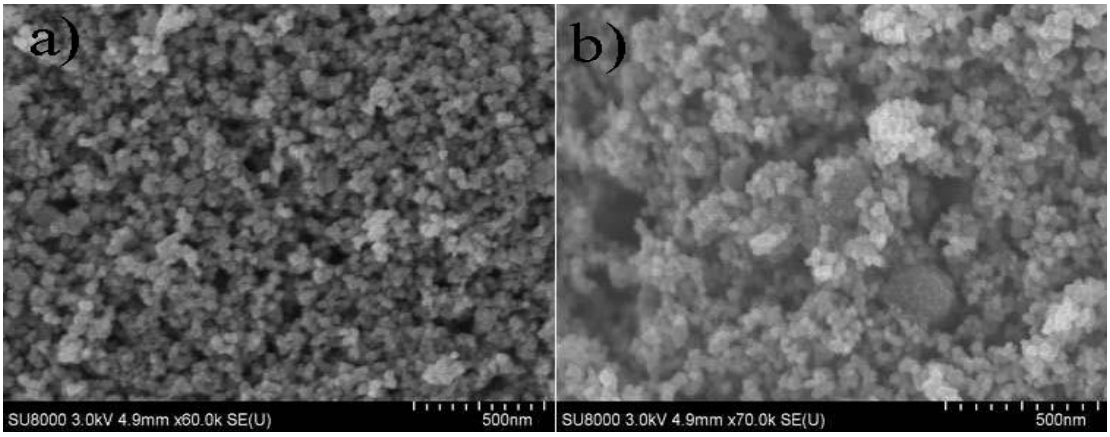

Fig. S9 The SEM images of different photoanode films: a) pure TiO_2 film; b) T3@TiO_2 film, which showed that pure TiO_2 film consisted of uniform TiO_2 particles, whereas T2@TiO_2-doped film contained some agminated micropore ball.

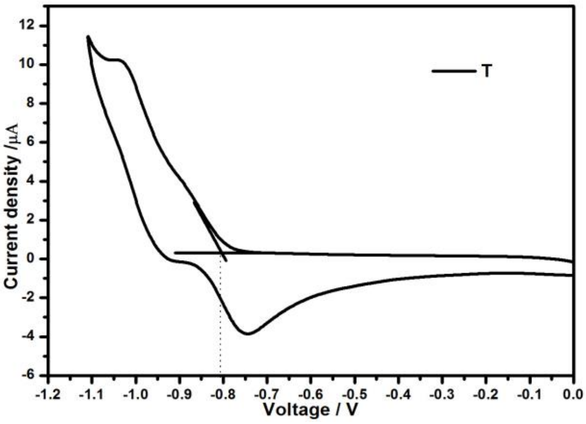

Fig. S10 Cyclic voltammetry curve of the T in 0.5M HAc/NaAc buffer solution with pH =6.00 in the voltage range from 0 V to -1.2 V

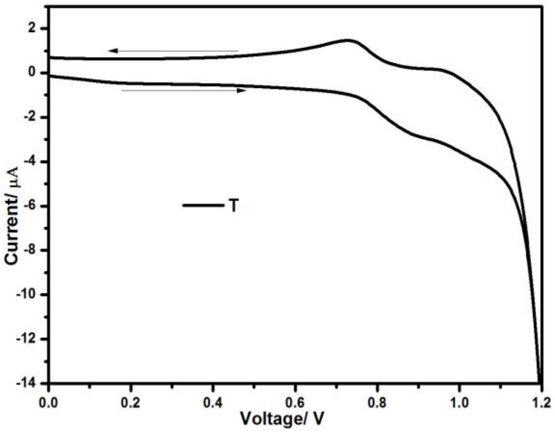

Fig. S11 Cyclic voltammetry curve of the T in 0.5M HAc/NaAc buffer solution with pH =6.00 in the voltage range from 0V to 1.2V .

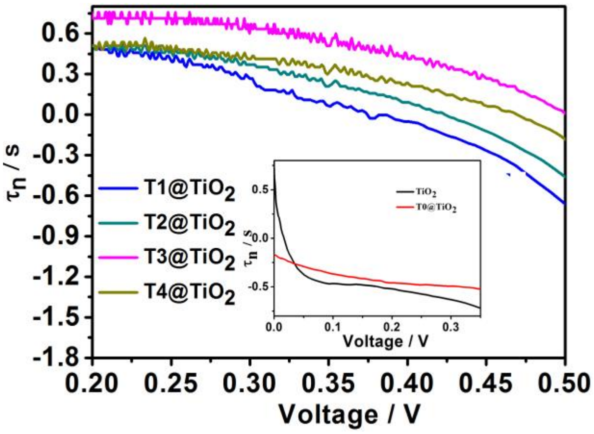

Fig. S12 the electron lifetime calculated from OCVD of CdSe sensitized T1@TiO$_2$, T2@TiO$_2$, T3@TiO$_2$ and T4@TiO$_2$ cells; the Inset) the electron lifetime calculated from OCVD of CdSe sensitized pure TiO$_2$ and T0@TiO$_2$ cells.

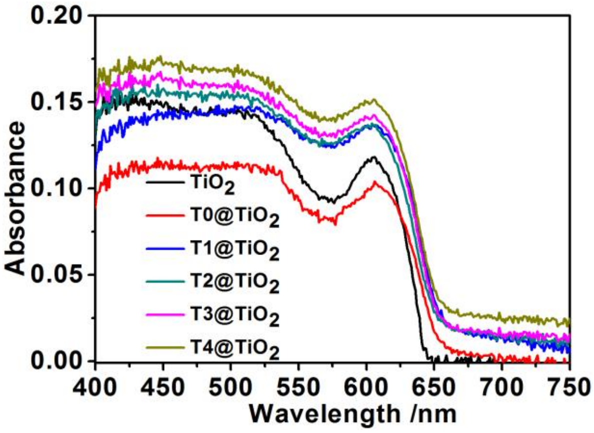

Fig. S13 UV-vis absorption spectra of CdSe sensitized pure TiO_2 and T@TiO_2 photoanode films after deposition for 6h.

Absorption spectra of CdSe sensitized pure TiO_2 and T@TiO_2 photoanode films were shown in Fig. S13. As can be see from the Fig. S13, the absorbance of CdSe sensitized T0@TiO_2 photoanode films are slightly larger than the CdSe sensitized pure TiO_2 photoanode films. The possible reason is that the large particles of TiO_2 are conducive to the absorption of the spectrum. Furthermore, the absorbance of CdSe sensitized T@TiO_2 (T1@TiO_2, T2@TiO_2, T3@TiO_2, T4@TiO_2) photoanode films increased with the increase of the content of T. And the absorbance of CdSe sensitized T@TiO_2 (T1@TiO_2, T2@TiO_2, T3@TiO_2, T4@TiO_2) photoanode films are obvious wider than the CdSe sensitized pure TiO_2 photoanode films in the range from the 550 to 600nm and after 650nm. Experimental results show that T added to the photoanodes as collaborative cosensitizer can constitute a wider spectrum of absorption.

Table S1 Simulated values of resistance (Rrec) and capacitance (Cμ) for cell devices based on CdSe sensitized pure TiO_2 and T@TiO_2 photoanodes at the forward bias of −0.60 V.

Cells	TiO_2	T0@TiO_2	T1@TiO_2	T2@TiO_2	T3@TiO_2	T4@TiO_2
R_{rec}/ Ω cm^{-2}	49	65	153	254	310	144
C_{μ}/ mF cm^{-2}	3.21	3.23	3.31	3.39	3.27	3.18

References

S1 M. Vasilopoulou, A. M. Douvas, L. C. Palilis, S. Kennou, and P. Argitis, *J. Am. Chem. Soc*. 2015, **137**, 6844−6856.