**Electronic Supplementary Information (ESI)**

# Preparation of $YbF_3$-Ho@$TiO_2$ core-shell sub-microcrystal spheres and their application to the electrode of dye-sensitized solar cells

Jia Yu,[a,b,c]* Yulin Yang,[d,]* Chuanxiang Zhang,[b,e]* Ruiqing Fan,[d] Ting Su[f]

[a] *Hami Vocational &Technical College, Hami, 839000, P. R. China.*

[b] *Henan Key Laboratory of Coal Green Conversion, College of Chemistry and Chemical Engineering, Henan Polytechnic University, Jiaozuo, 454003, P. R. China.*

[c] *Hami Yuxin Energy Industry Research Institute Co., Ltd., 839000, P. R. China.*

[d] *MIIT Key Laboratory of Critical Materials Technology for New Energy Conversion and Storage, School of Chemistry and Chemical Engineering, Harbin Institute of Technology, Harbin 150001, P. R. China.*

[e] *Collaborative Innovation Center of Coal Work Safety, Jiaozuo, 454003, P. R. China.*

[f] *Green Chemistry Centre, College of Chemistry and Chemical Engineering, Yantai University, Yantai 264005, P. R. China.*

*Corresponding Authors E-mail addresses:*
*yujiade1987@126.com; ylyang@hit.edu.cn and zcx223@hpu.edu.cn.*

**SUPPLEMENT**

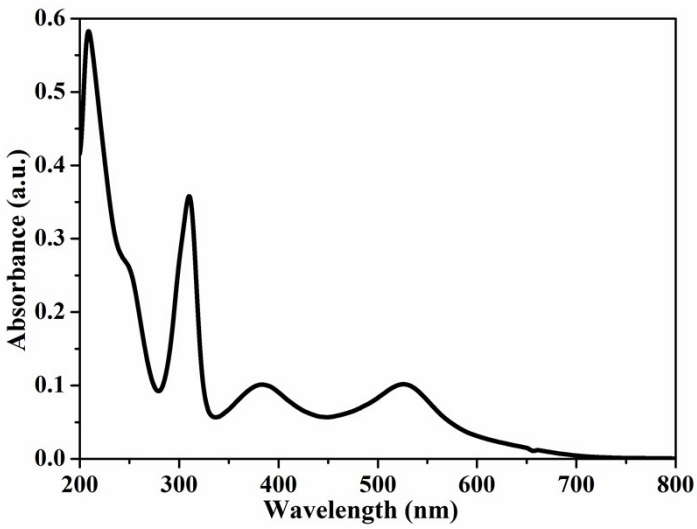


**Fig. S1** The absorbance spectrum of N719 dye in ethylalcohol.

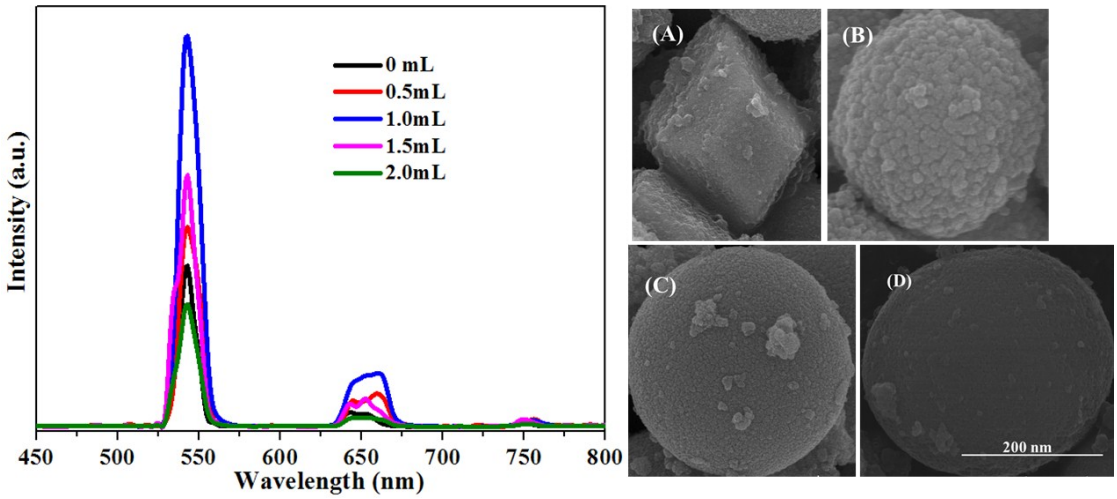


**Fig. S2** Upconversion emission spectra of $YbF_3$-Ho@$TiO_2$ with different amount of titanium isopropylate in the synthesis process and the inset are their corresponding SEM images (A) 0.5 mL, (B) 1mL, (C) 1.5 mL and (D) 2 mL.

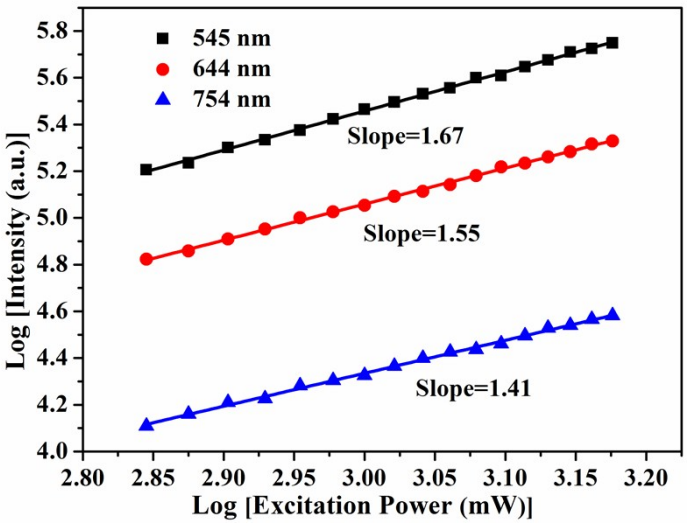


**Fig. S3** The upconversion emission intensity as a function of excitation power from a 980 nm laser at 545 nm, 644nm and 754 nm for $YbF_3$-Ho@$TiO_2$.

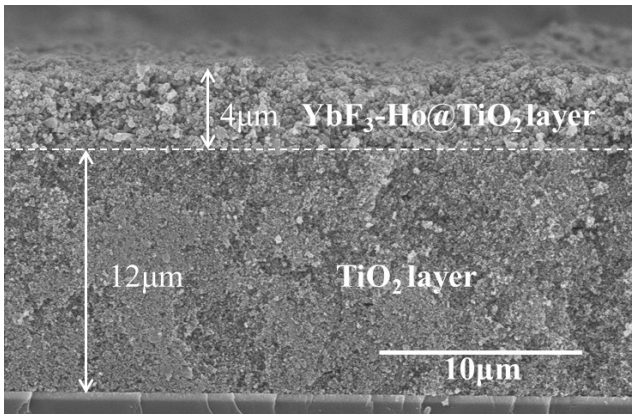


**Fig. S4** Cross-section SEM image of $TiO_2$/$YbF_3$-Ho@$TiO_2$ heterostructured photoanode film.

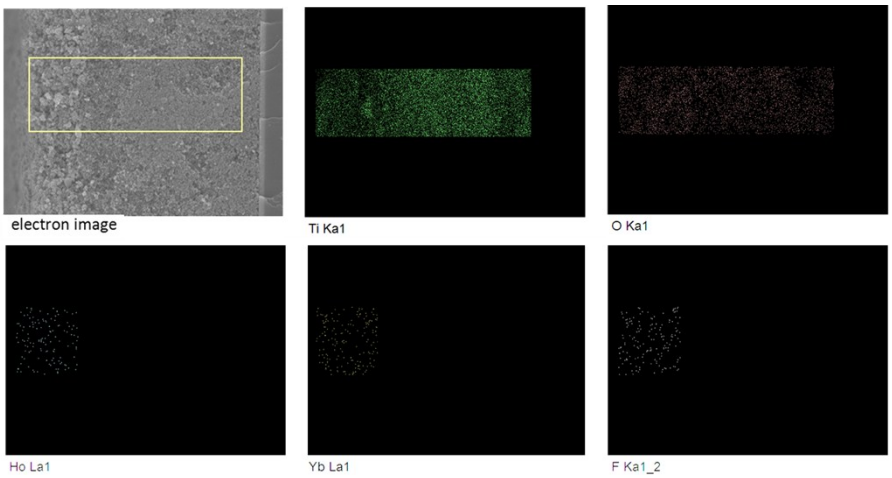


**Fig. S5** Element mapping of the cross-section $TiO_2$/$YbF_3$-Ho@$TiO_2$ heterostructured

photoanode film.

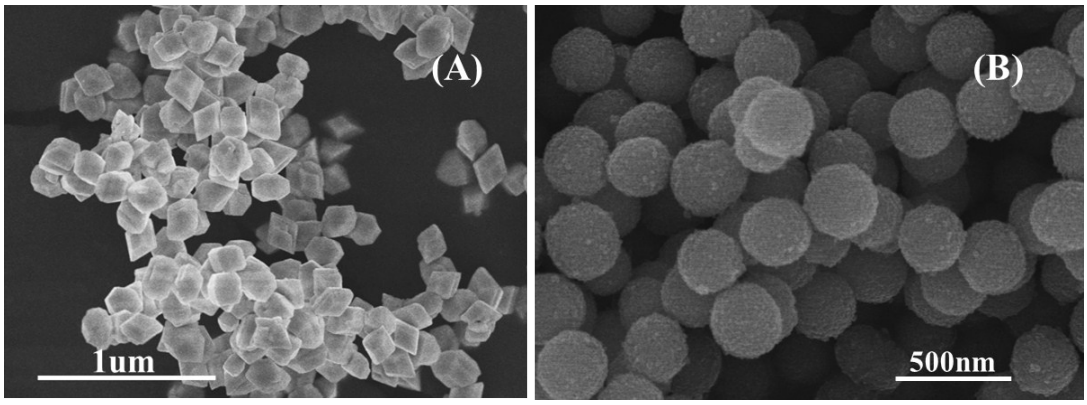


**Fig. S6** SEM images of (A) $YbF_3$ and (B) $YbF_3@TiO_2$.

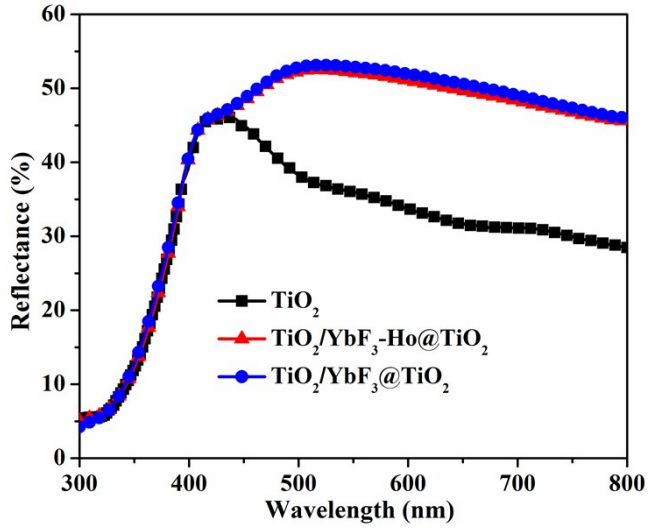


**Fig. S7** Diffused reflectance spectra of different photoanode films.

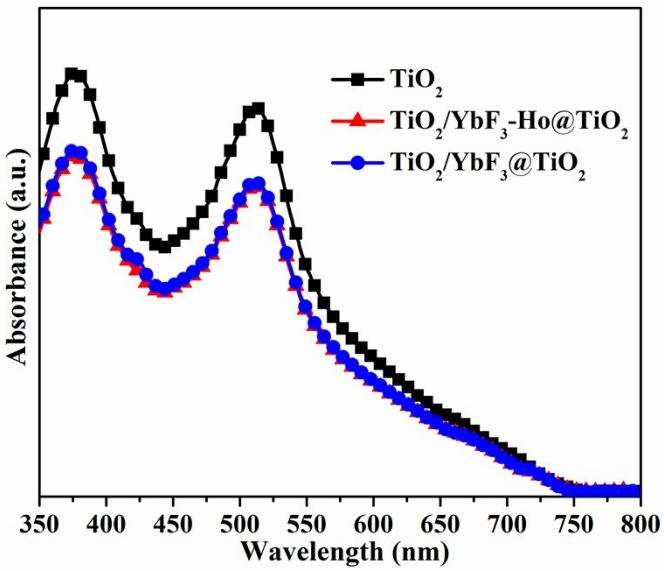


**Fig. S8** UV-vis spectra of desorbed dye solutions from sensitized photoanodes.

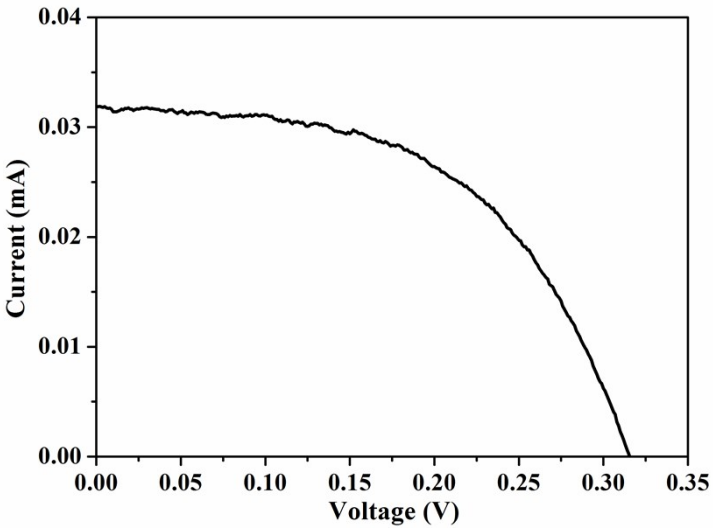


**Fig. S9** Photocurrent-voltage curve of DSSC with $TiO_2/YbF_3$-Ho@$TiO_2$ under 980 nm laser illumination.

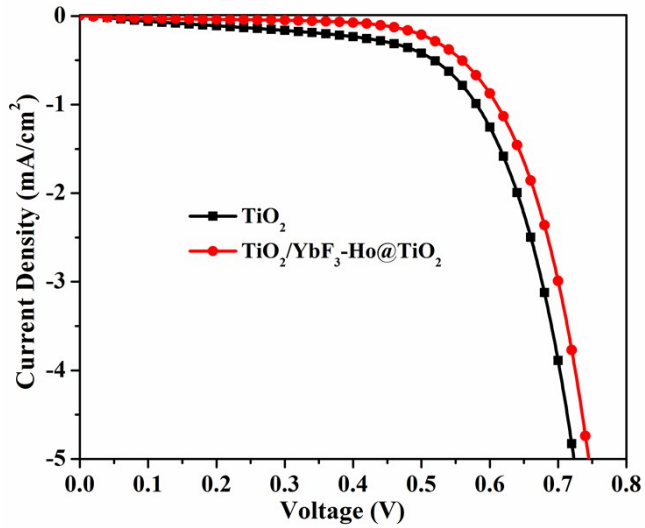


**Fig. S10** Dark current-voltage curves of DSSCs assembled with $TiO_2$ and $TiO_2/YbF_3$-Ho@$TiO_2$ photoanodes.