Supporting materials:

Enhanced Performance of Dye-sensitized Solar Cells by Utilization of An External, Bifunctional Layer Consisting of Uniform *β*-$NaYF_4:Er^{3+}/Yb^{3+}$ Nanoplatelets

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1. Material and methods

1.1. Synthesis of uniform *β*-$NaYF_4:Er^{3+}/Yb^{3+}$ hexagonal nanoplatelets

The nanoplatelets were synthesized via the modification of a reported hydrothermal synthesis route. In a typical procedure for the preparation of *β*-$NaYF_4$:2% Er^{3+}/18% Yb^{3+} hexagonal nanoplatelets, $Er(NO_3)_3{\cdot}5H_2O$ (0.04 mmol), $Yb(NO_3)_3{\cdot}5H_2O$ (0.36 mmol), and $Y(NO_3)_3{\cdot}6H_2O$ (1.6 mmol) were added into 40 mL aqueous solution containing sodium citrate dihydrate (11 mmol) followed by the addition of sodium fluoride (18 mmol) and stirring for 15 min. Then, the mixed solution was transferred into a bomb with teflon-liner (125 mL, supplied by Parr Instruments) and heated at 200~240 °C for 20 h. After this, the precipitates were separated by centrifugation, washed with ethanol and deionized water, and then dried in air at 60°C for 24 h. Different-sized *β*-$NaYF_4:Er^{3+}/Yb^{3+}$ platelets were obtained by adjusting the amounts of sodium citrate and sodium fluoride.

1.2. Analysis methods

X-ray powder diffraction (XRD) analysis was performed on a Rigaku Rotaflex D-Max diffractometer equipped with a rotating anode, a copper target ($\lambda_{(CuK\alpha)}$ = 1.5406 Å), a monochromator composed of a graphite crystal and a scintillator detector. The diffractometer used 40 kV and 20 mA. Scanning took place between 10° and 90 ° (2θ) with a 0.1° step and an acquisition time of 10 s per step. Scanning Electron Microscopy (SEM) images were obtained

using a Hitachi S-4700 FE-SEM. Transmission Electron Microscopy (TEM) images were obtained using a Philips CM-200 microscope operating at 200 kV. Upconversion fluorescence spectra (Fig.2) were measured on a PTI Fluorescence spectrophotometer by using a 980 nm laser (UH5 100G-980, 100 mW, World Star Tech) to replace the A-1010 arc lamp.

2. Characterization of the $NaYF_4:Er^{3+}/Yb^{3+}$ nanoplatelets

TEM images of the as-prepared $NaYF_4:Er^{3+}/Yb^{3+}$ nanoplatelets are shown in **Fig.S1-1**. XRD patterns (**Fig.S2**) of the nanoplatelets clearly show that are made of crystalline pure hexagonal β phase as further demonstrated in **Fig.S2** (β-$NaYF_4$ (JCPDS No. 16-0334), β-$NaErF_4$ (JCPDS No. 27-0689) and β-$NaYbF_4$ (JCPDS No. 27-1427). Er^{3+} and Yb^{3+} are doped into the host lattices of β-$NaYF_4$.

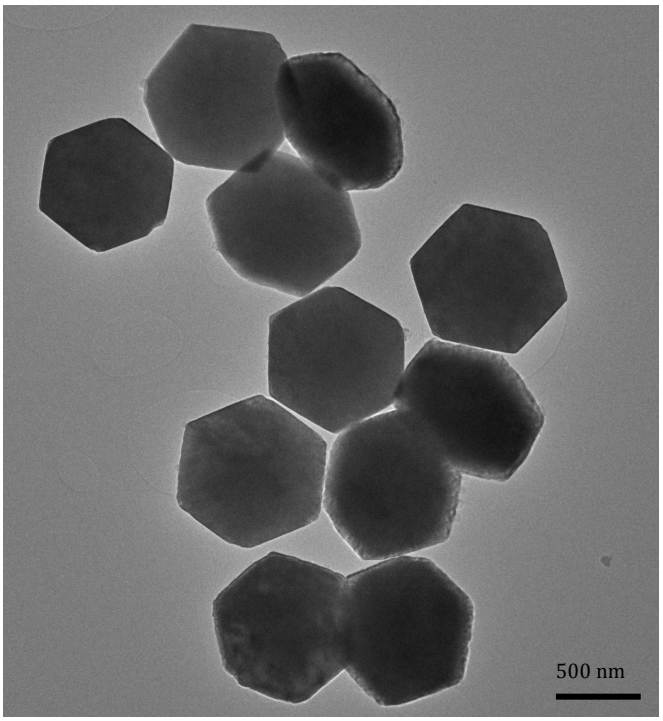

Fig. S1 TEM image of the prepared β-$NaYF_4:Er^{3+}/Yb^{3+}$ nanoplatelets

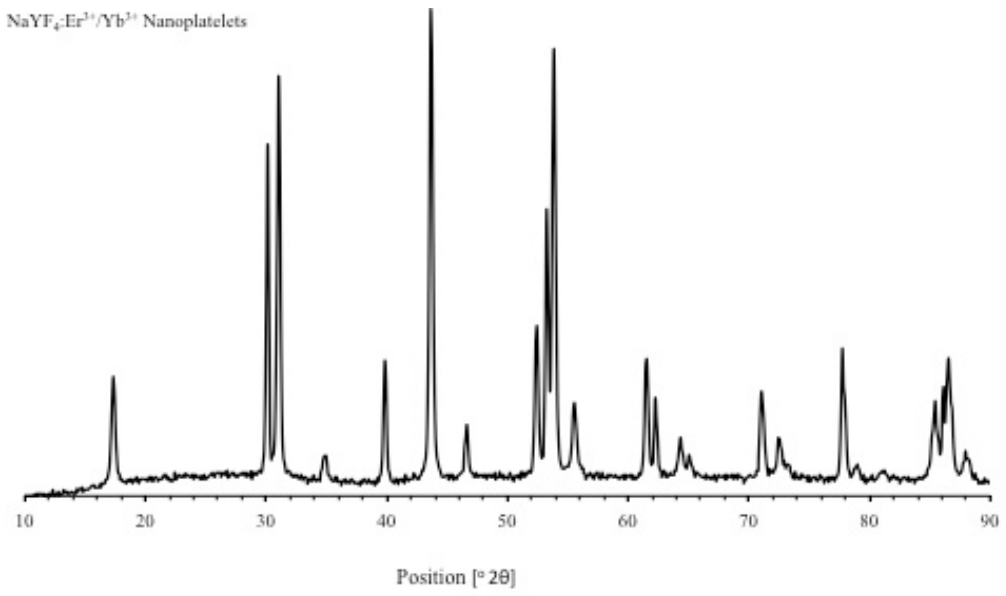

Fig.S2 XRD patterns of the prepared β-$NaYF_4$:Er^{3+}/Yb^{3+} nanoplatelets

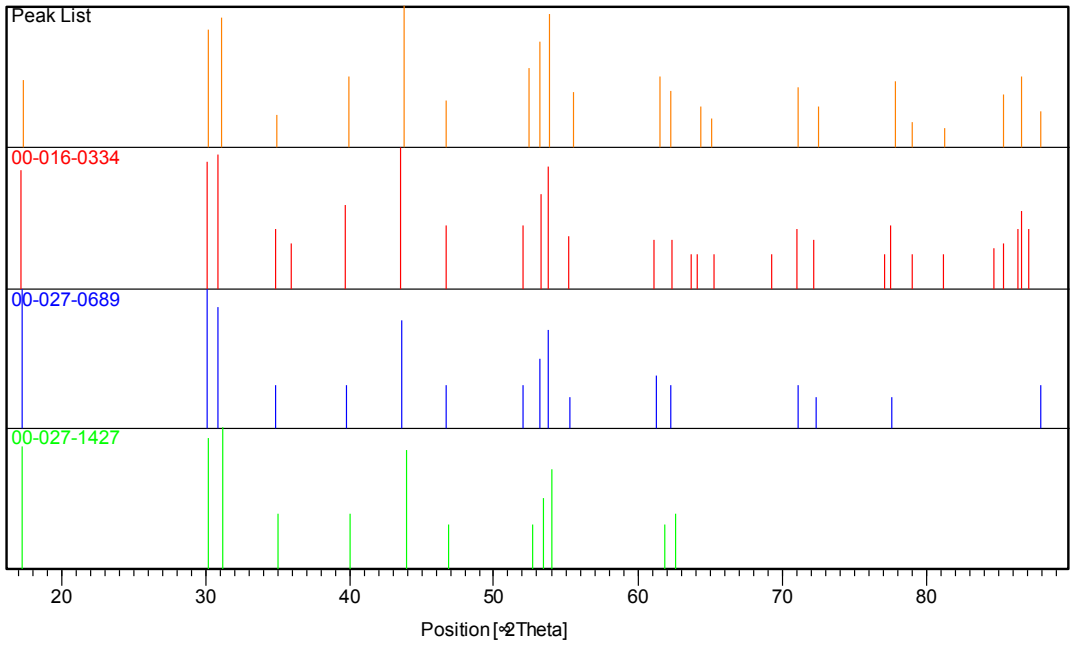

Fig. S3 XRD peak list of the prepared β -$NaYF_4$:Er^{3+}/Yb^{3+} nanoplatelets and the literature data, β-$NaYF_4$ (JCPDS no. 16-0334), β-$NaErF_4$ (JCPDS no. 27-0689) and β-$NaYbF_4$ (JCPDS no. 27-1427)

3. SEM images of external layers

Fig.S4 shows the morphologies of external layers made from different-sized β-$NaYbF_4$ platelets.

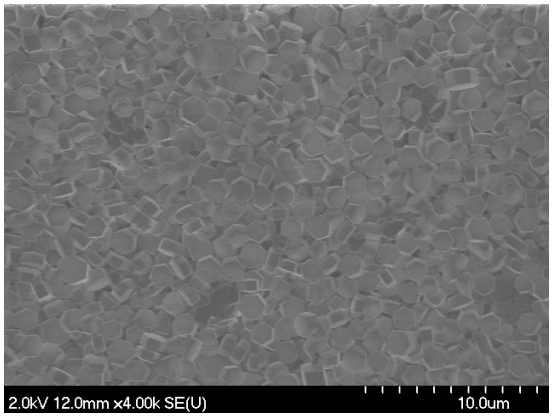

Fig.S4-1 External layer of the device AB0

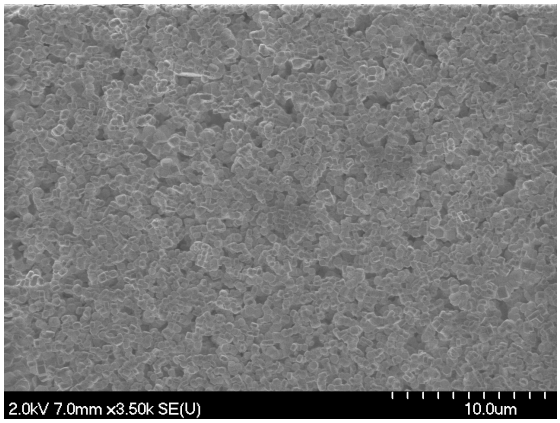

Fig.S4-2 External layer of the device AC0