Electronic Supplementary Information

A red phosphor $BaTiF_6:Mn^{4+}$: reaction mechanism, microstructures, optical properties, and applications for white LEDs

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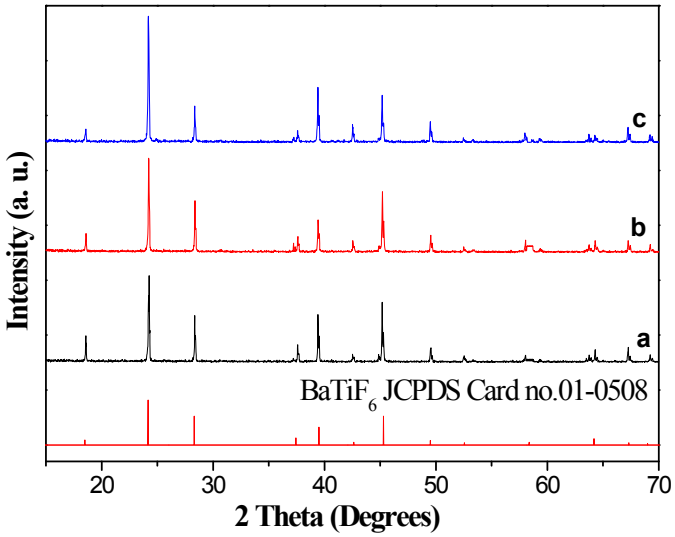

Figure S1. XRD patterns of the as-synthesized red phosphors $BaTiF_6:Mn^{4+}$ obtained from etching $Ti(OC_4H_9)_4$ in HF at (a) 80 °C, (b) 120 °C, and 240 °C for 20 h.

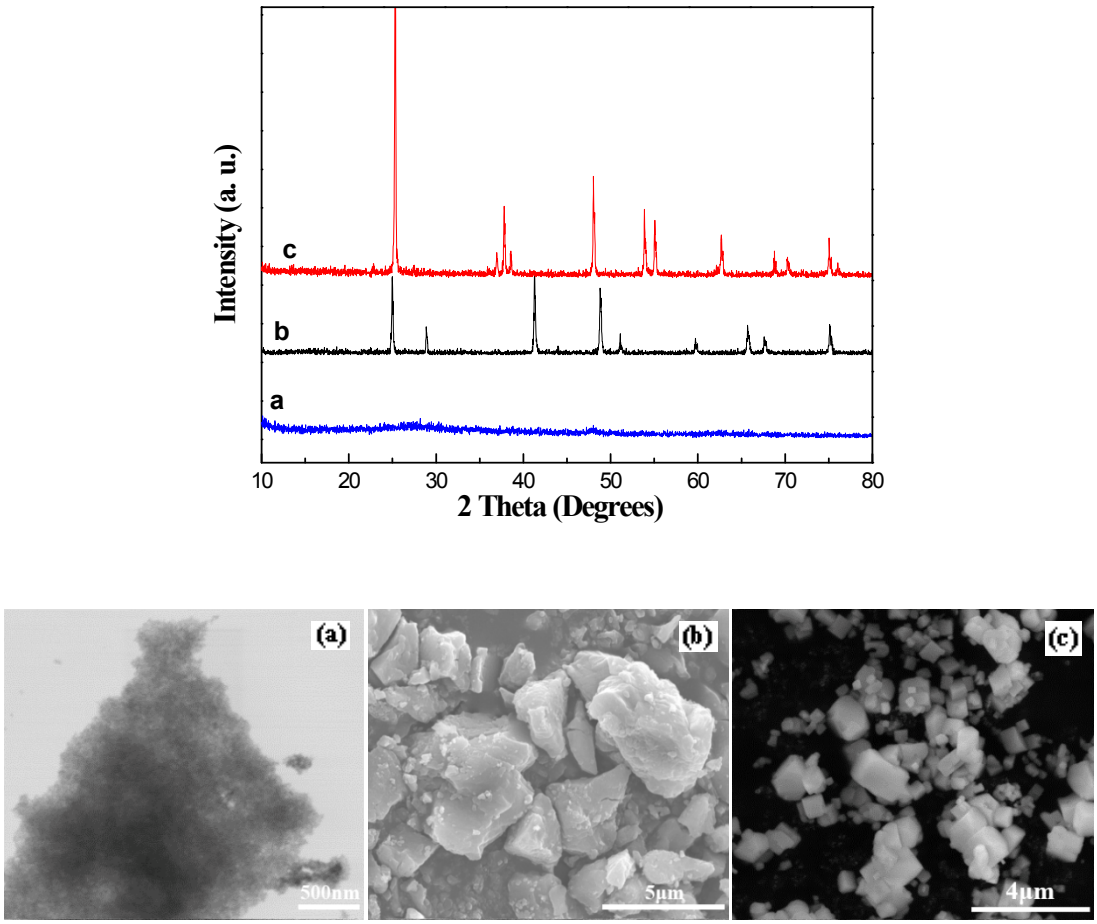

Figure S2. XRD patterns and SEM images of raw materials (a) TiO_2 nanoparticles hydrolyzed from $Ti(OC_4H_9)_4$, (b) TiO_2 and (c) BaF_2 commercially obtained.

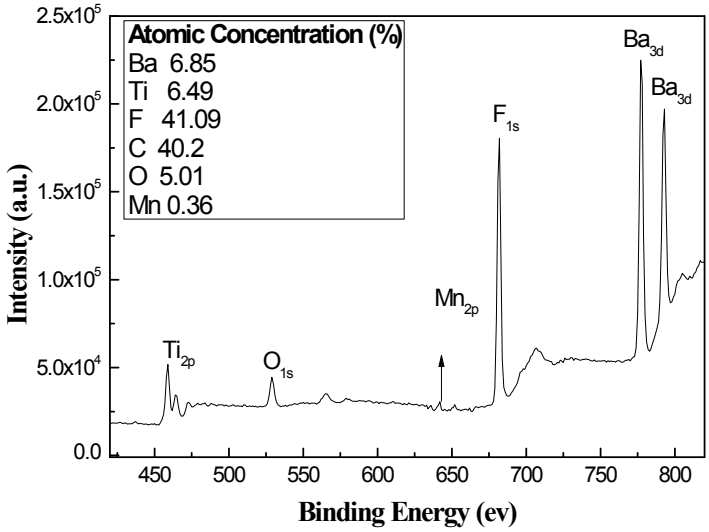

Figure S3. XPS survey spectrum of red phosphor $BaTiF_6:Mn^{4+}$.

The binding energy of $BaTiF_6:Mn^{4+}$ was examined by x-ray photoelectron spectroscopy (XPS, ESCALAB MKII), and all the peaks were calibrated by using C1s at 284.60 eV as the reference.

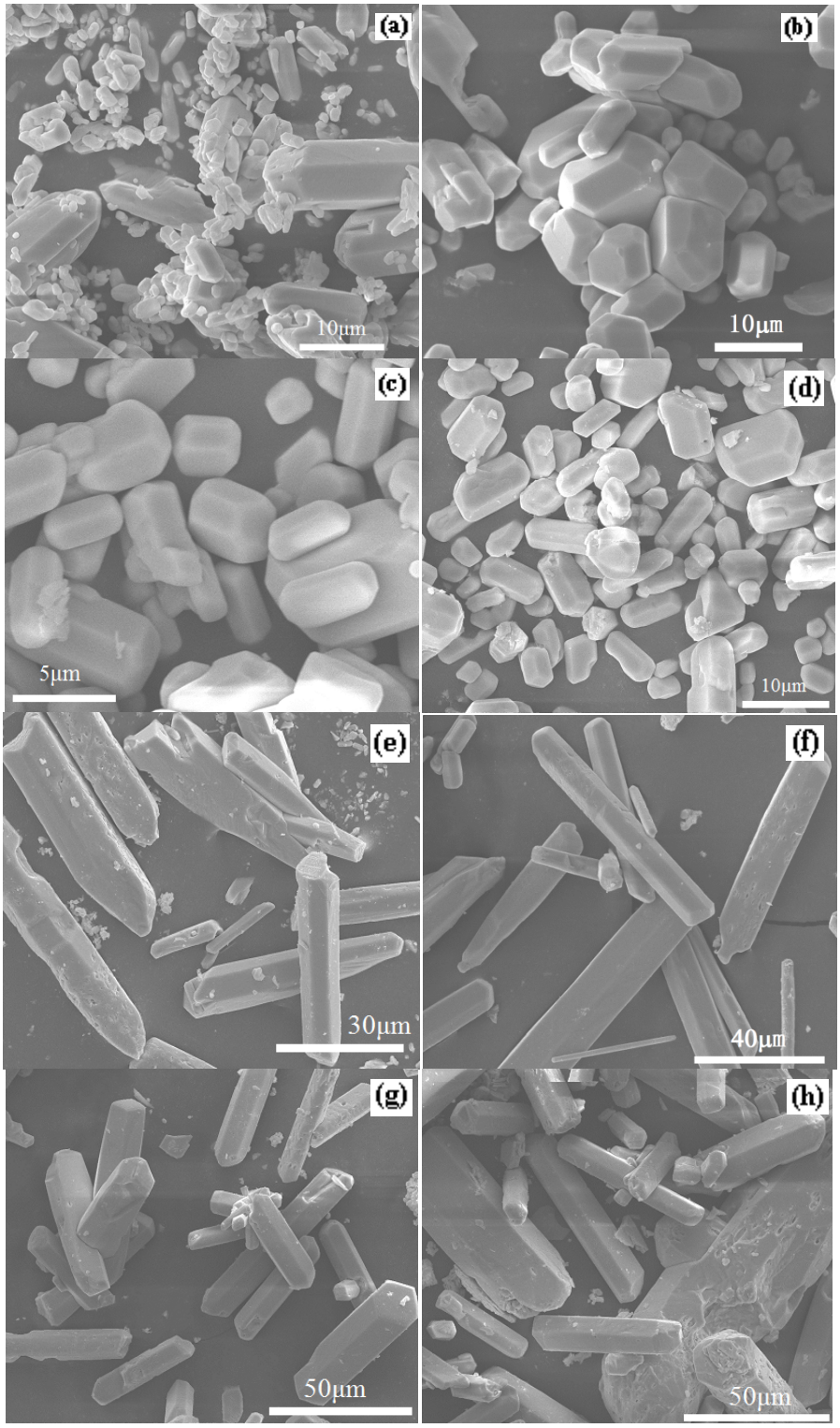

Figure S4. SEM the as-synthesized red phosphors $BaTiF_6:Mn^{4+}$ from $Ti(OR)_4$ at (a) 80, (b) 120, (c) 180, (d) 240 °C for 20 h, and from TiO_2 at (e) 80, (f) 120, (g) 180, (h) 240 °C for 20 h,

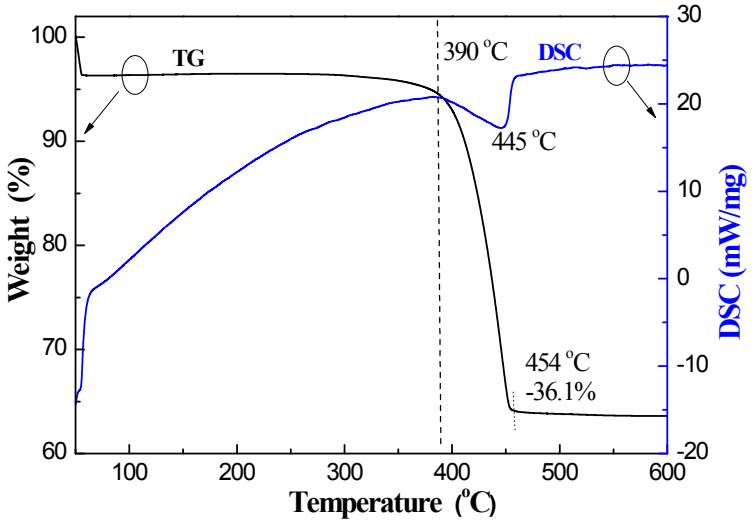

Figure S5. Thermogravimetrics (TG) and different scanning calorimeter (DSC) graphs of as synthesized $BaTiF_6:Mn^{4+}$ under N_2 atmosphere. The data were obtained on TG analysis and DSC (Netzsch STA 449C, at a heating rate of 10K/min).

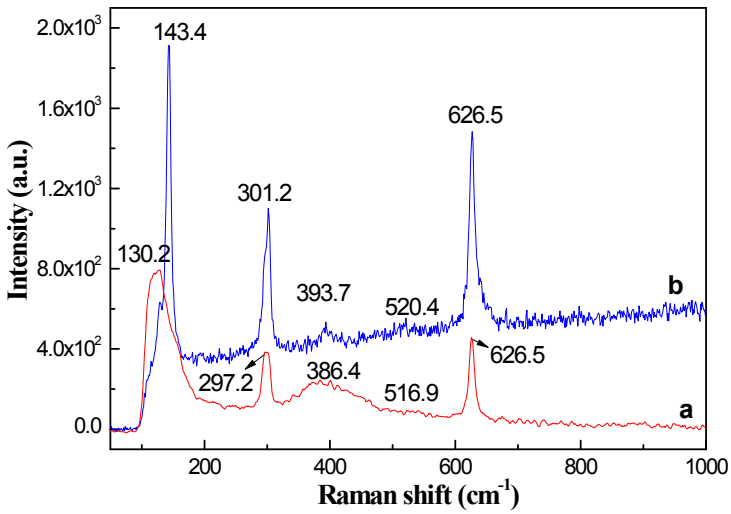

Figure S6. Raman spectra of the as-synthesized red phosphor (a) $BaTiF_6:Mn^{4+}$ and (b) undoped $BaTiF_6$ measured on a JY-T64000 Raman spectroscopy at room temperature. Note: both samples are prepared from $Ti(OC_4H_9)_4$ and the wavelength of the laser excitation is 632.8 nm (1.96 eV, 3 mW).

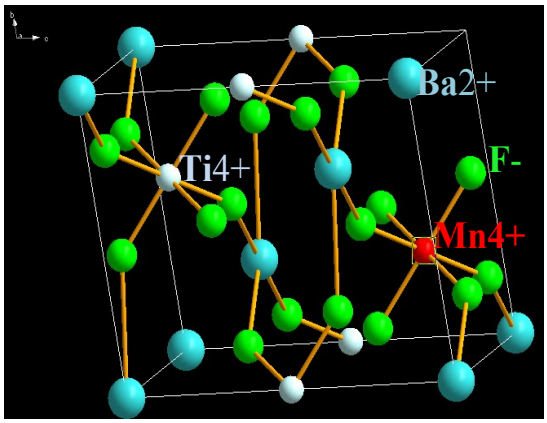

Figure S7. The structure projection of $BaTiF_6:Mn^{4+}$ plotted by software Diamond 3.1.

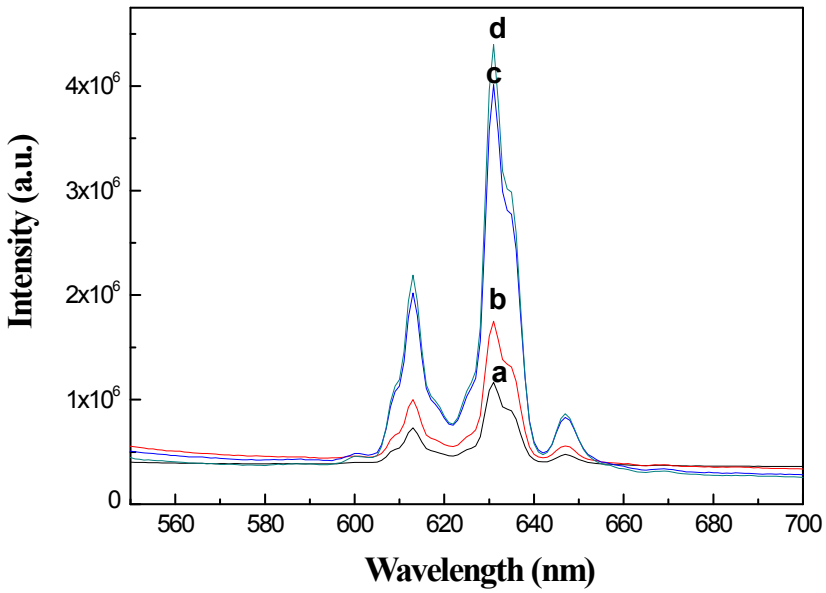

Figure S8. Emission spectra (ex=460 nm) of the as-synthesized red phosphor $BaTiF_6:Mn^{4+}$ obtained from starting materials BaF_2, HF, $KMnO_4$ and $Ti(OC_4H_9)_4$ at (a) 80 °C, (b) 100 °C, (c) 120 °C, and (d) 240 °C for 20 h.

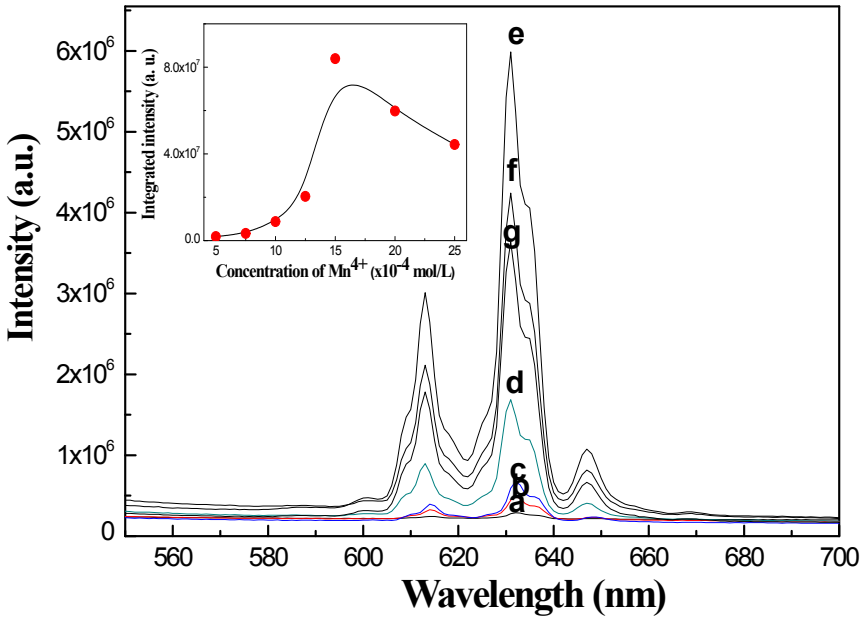

Figure S9. Dependence of emission spectra of $BaTiF_6:Mn^{4+}$ on the concentration of $KMnO_4$ at (a) 0.05, (b) 0.75, (c) 1.0, (d) 1.25, (e) 1.5, (f) 2.0, (g) 2.5 (unit: mmol/L).

Table S1 The performance parameters of the white LEDs fabricated with InGaN chip, yellow phosphor YAG:Ce, and red phosphor $BaTiF_6:Mn^{4+}$. The WLED was examined by a LEE300E UV-Vis-near IR Spectrophotocolorimeter (Everfine photo-E-Infor Co., China) instrument.

Coordinates of international d'Eclairage	Intensity (mcd) 5φ20mA	Efficiency (lm/W)	Color temperature (K)	Color rendering index
(0.366,0.331)	2552.8	121	4073.1	93.13