Electronic Supplementary Information

Insights into luminescence thermal quenching of Mn4+-doped BaLa(Na/Li)(W/Te)O6 double perovskite red phosphors

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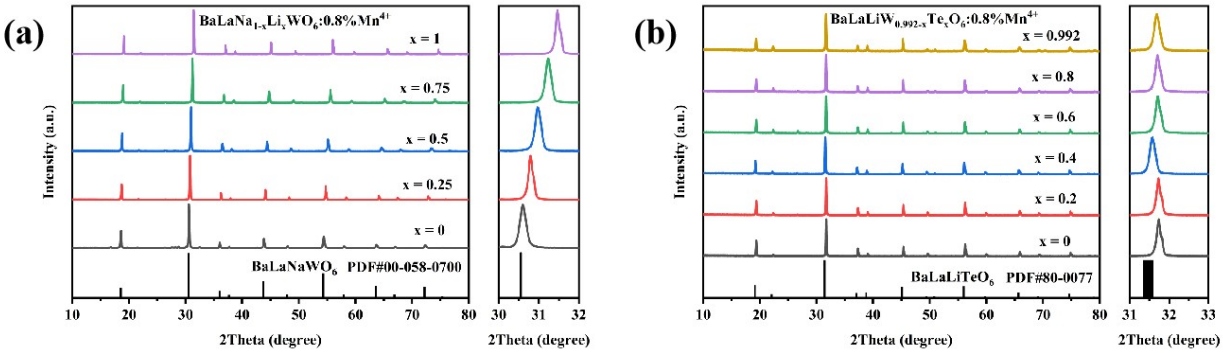


Figure S1: XRD patterns of synthesized (a) $BaLaNa_{1-x}Li_xWO_6$:0.8%Mn^{4+} and (b) $BaLaLiW_{0.992-x}Te_xO_6$:0.8%Mn^{4+}.

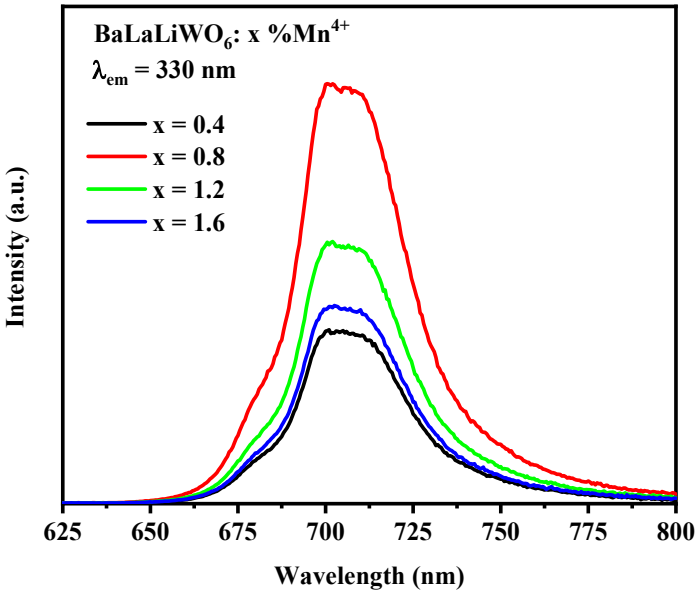


Figure S2: PL spectra of $BaLaLiWO_6$:x $\%Mn^{4+}$ (x = 0.4, 0.8, 1.2, 1.6) upon Mn^{4+} excitation at 330 nm

Table S1: Fractional atomic coordinates and isotropic displacement parameters of $BaLaNaWO_6$:0.8%Mn^{4+}

	x	y	z	B	Occ
Ba	0.25000	0.25000	0.25000	0.300	0.500
La	0.25000	0.25000	0.25000	0.300	0.500
Na	0.00000	0.00000	0.00000	1.000	1.000
W	0.50000	0.50000	0.50000	0.200	0.990
Mn	0.50000	0.50000	0.50000	0.200	0.010
O	0.26500	0.00000	0.00000	1.500	1.000

Table S2: Fractional atomic coordinates and isotropic displacement parameters of $BaLaLiWO_6$:0.8%Mn^{4+}

	x	y	z	B	Occ
Ba	0.25000	0.25000	0.25000	0.300	0.500
La	0.25000	0.25000	0.25000	0.300	0.500
Li	0.00000	0.00000	0.00000	1.000	1.000
W	0.50000	0.50000	0.50000	0.200	0.990
Mn	0.50000	0.50000	0.50000	0.200	0.010
O	0.26001	0.00000	0.00000	1.500	1.000

Table S3: Fractional atomic coordinates and isotropic displacement parameters of $BaLaLiTeO_6$:0.8%Mn^{4+}

	x	y	z	B	Occ
Ba	0.25000	0.25000	0.25000	0.300	0.500
La	0.25000	0.25000	0.25000	0.300	0.500
Li	0.00000	0.00000	0.00000	1.000	1.000
Te	0.50000	0.50000	0.50000	0.200	0.990
Mn	0.50000	0.50000	0.50000	0.200	0.010
O	0.26151	0.00000	0.00000	1.500	1.000

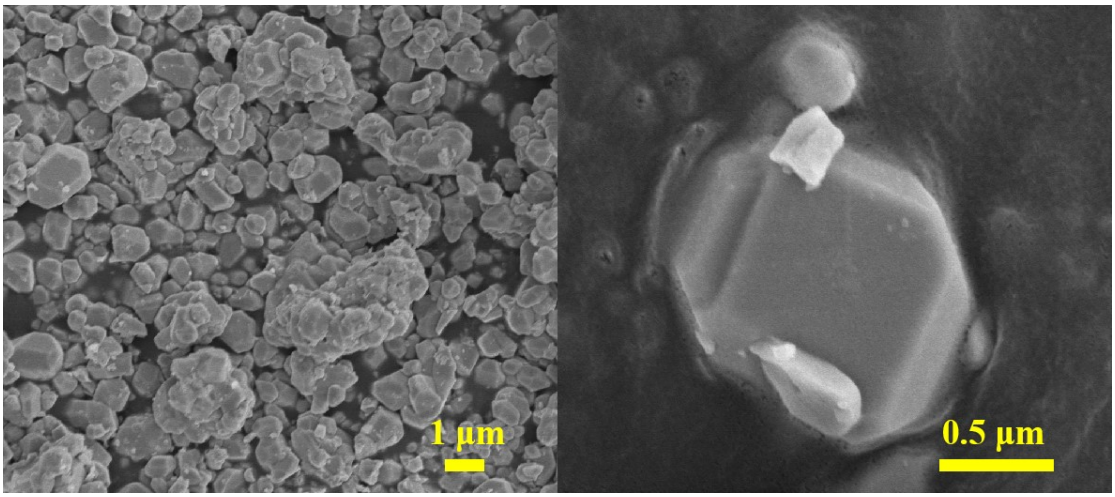


Figure S3: SEM images of the as-prepared $BaLaLiTeO_6$:0.8%Mn^{4+}.

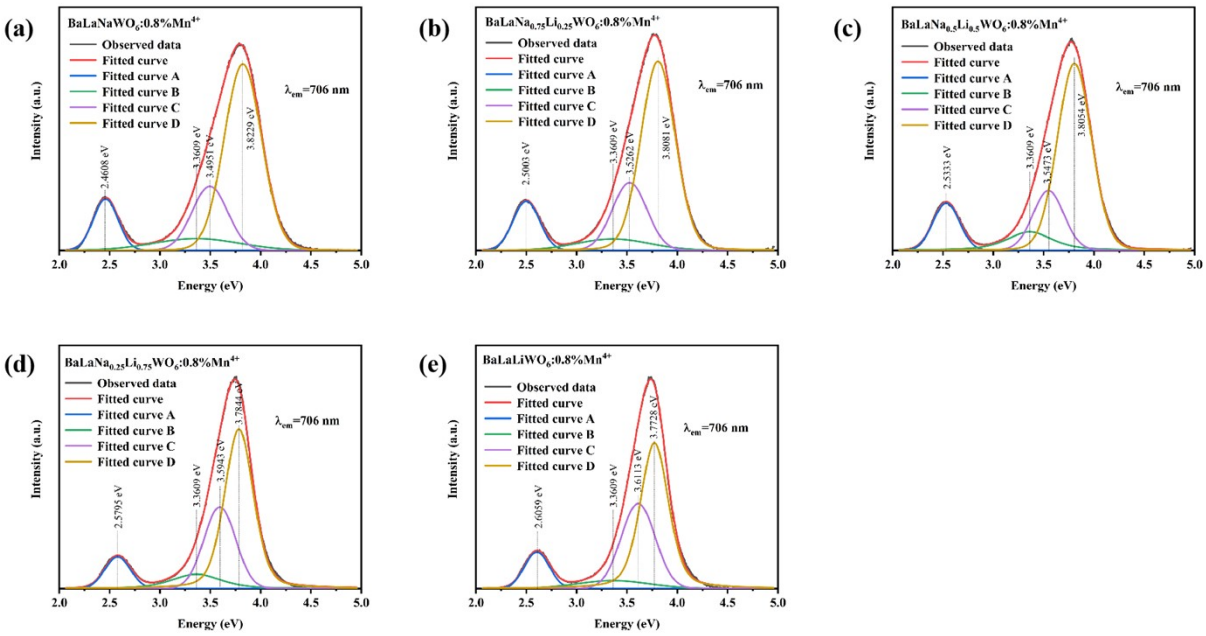


Figure S4: Gaussian fitting of BaLaNa1-xLixWO6:0.8%Mn^{4+} PLE spectra (a) x = 0; (b) x = 0.25; (c) x = 0.5; (d) x = 0.75; (e) x = 1.

Table S4: Position of each transition energy level in the excitation spectra of $BaLaNa_{1-x}Li_xWO_6$:0.8 %Mn^{4+} obtained by Gaussian fitting

	$^4A_{2g}\rightarrow{}^4T_{2g}$ (eV)	$^4A_{2g}\rightarrow{}^2T_{2g}$ (eV)	$^4A_{2g}\rightarrow{}^4T_{1g}$ (eV)	Mn^{4+}-O^{2-} (eV)
x=0	2.461	3.361	3.495	3.823
x=0.25	2.500	3.361	3.526	3.808
x=0.5	2.533	3.361	3.547	3.805
x=0.75	2.580	3.361	3.594	3.784
x=1	2.606	3.361	3.611	3.773

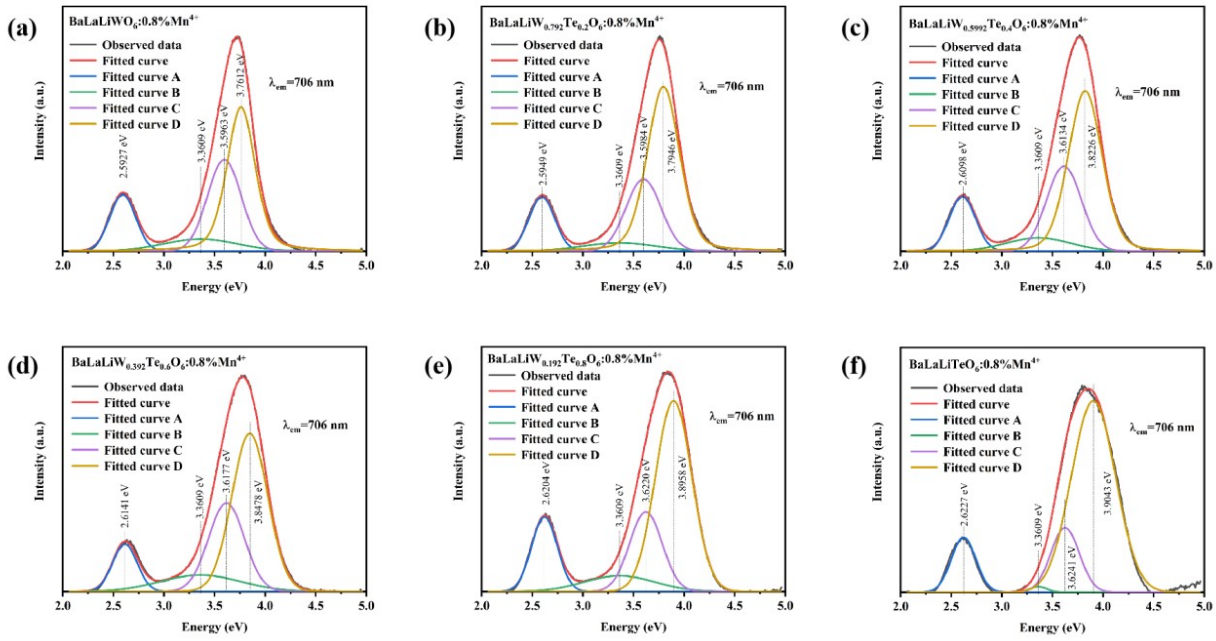


Figure S5: Gaussian function of PLE spectra of $BaLaLiW_{0.992-x}Te_xO6$:0.8%Mn^{4+} samples (a) x = 0; (b) x = 0.2; (c) x = 0.4; (d) x = 0.6; (e) x = 0.8; (e) x = 1.

Table S5: Energy of Mn^{4+} related transitions observed in $BaLaLiW_{0.992-x}Te_xO_6$:0.8 %Mn^{4+} as obtained by Gaussian fitting

	$^4A_{2g}\rightarrow{}^4T_{2g}$ (eV)	$^4A_{2g}\rightarrow{}^2T_{2g}$ (eV)	$^4A_{2g}\rightarrow{}^4T_{1g}$ (eV)	Mn^{4+}-O^{2-} (eV)

x=0	2.593	3.361	3.596	3.761
x=0.2	2.595	3.361	3.598	3.795
x=0.4	2.610	3.361	3.613	3.823
x=0.6	2.614	3.361	3.618	3.848
x=0.8	2.620	3.361	3.622	3.896
x=0.992	2.623	3.361	3.624	3.904

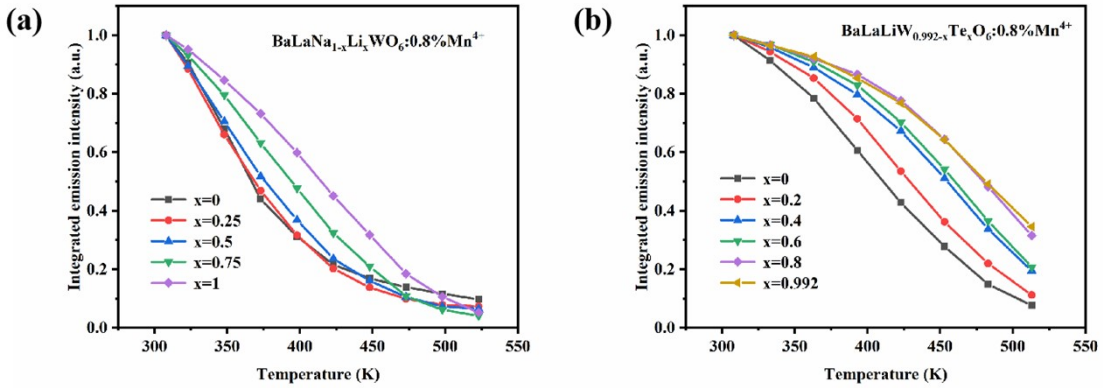
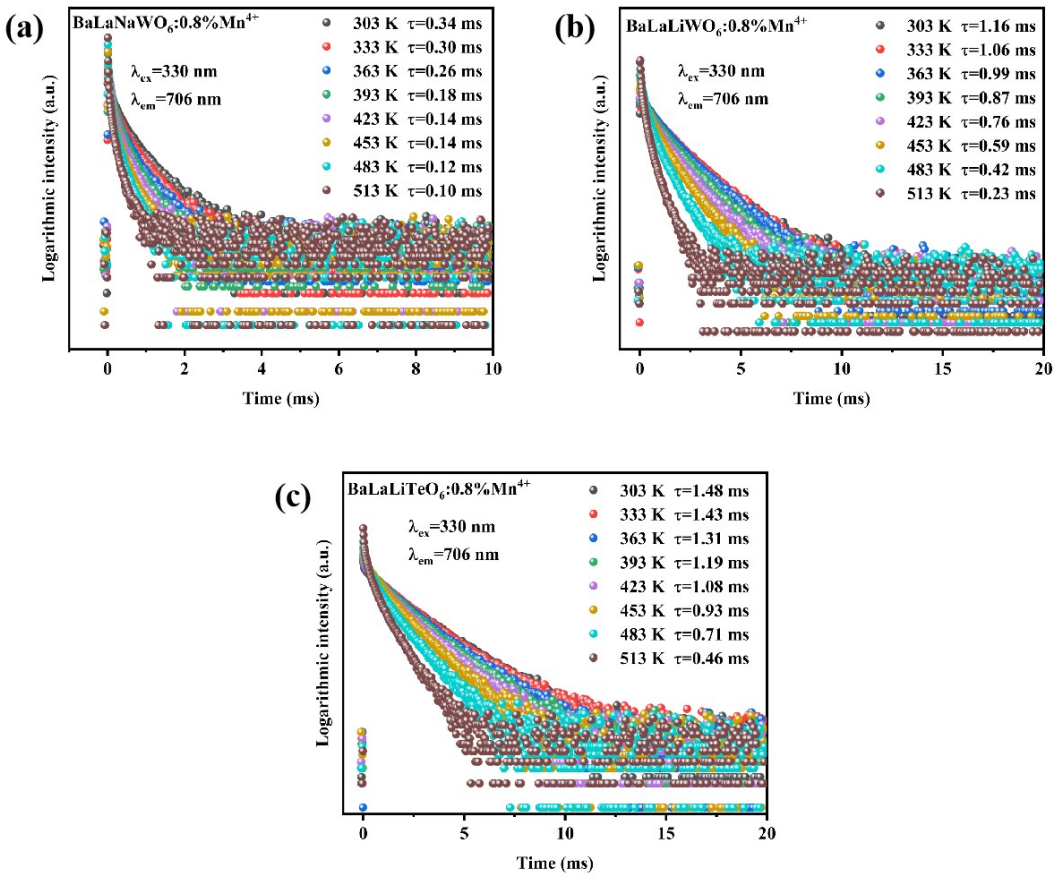


Figure S6: Temperature-dependent integrated emission intensity of (a) $BaLaNa_{1-x}Li_xWO_6$:0.8%Mn^{4+} and (b) $BaLaLiW_{0.992-x}Te_xO_6$:0.8%Mn^{4+}.



Figuse S7: Temperature-dependent decay curves of Mn^{4+} ^2E_g state in (a) $BaLaNaWO_6$:0.8%Mn^{4+} (b) $BaLaLiWO_6$:0.8%Mn^{4+} and (c) $BaLaLiTeO_6$:0.8%Mn^{4+} upon excitation at 330 nm.

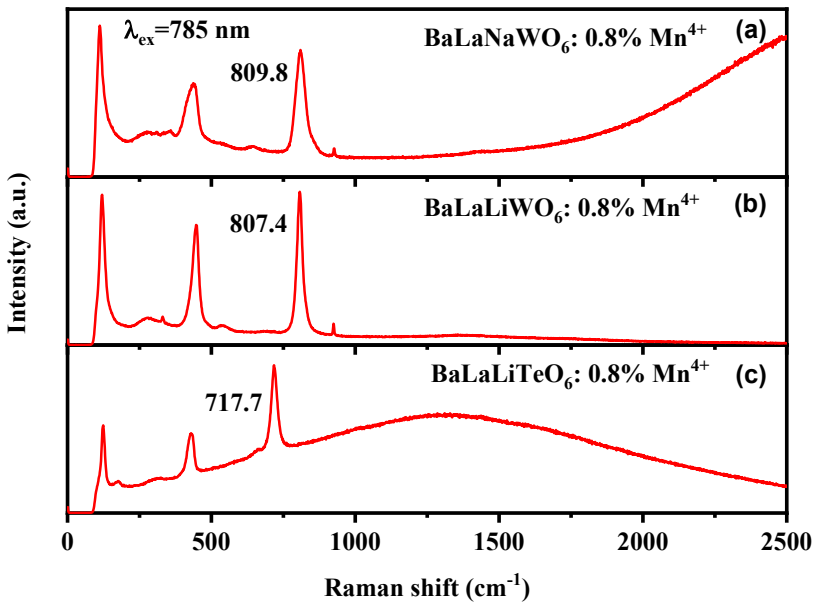


Figure S8: Raman spectra of (a) $BaLaNaWO_6$:0.8%Mn^{4+} (b) $BaLaLiWO_6$:0.8%Mn^{4+} and (c) $BaLaLiTeO_6$:0.8%Mn^{4+}.