

Electronic Supplementary Information (ESI)

**Surface lattice enhancement of red-emitting fluoride
enabled by embedding small cations**

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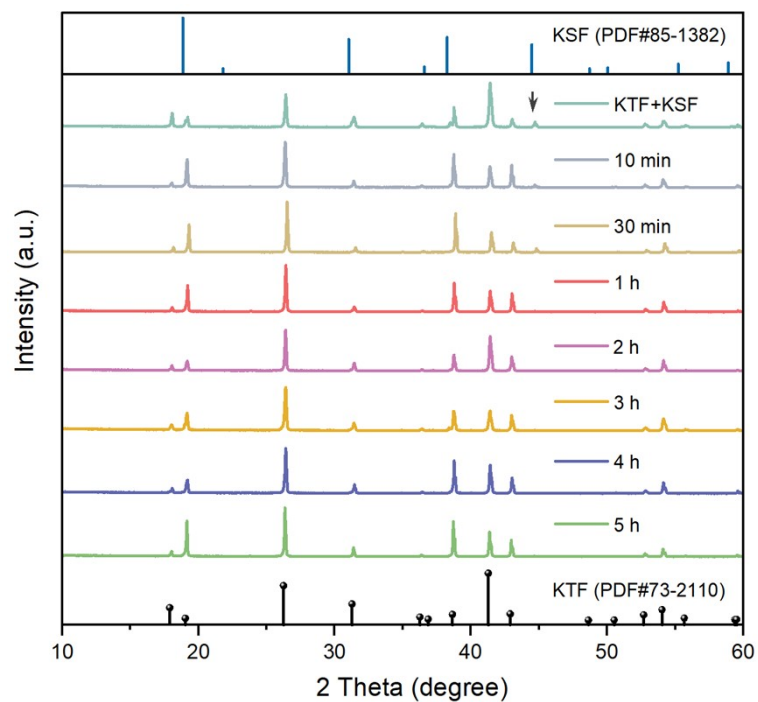


Fig. S1 XRD patterns of KTFM@KTSF synthesized for different reaction time (10 min, 30 min, 1 h, 2 h, 3 h, 4 h, 5 h).

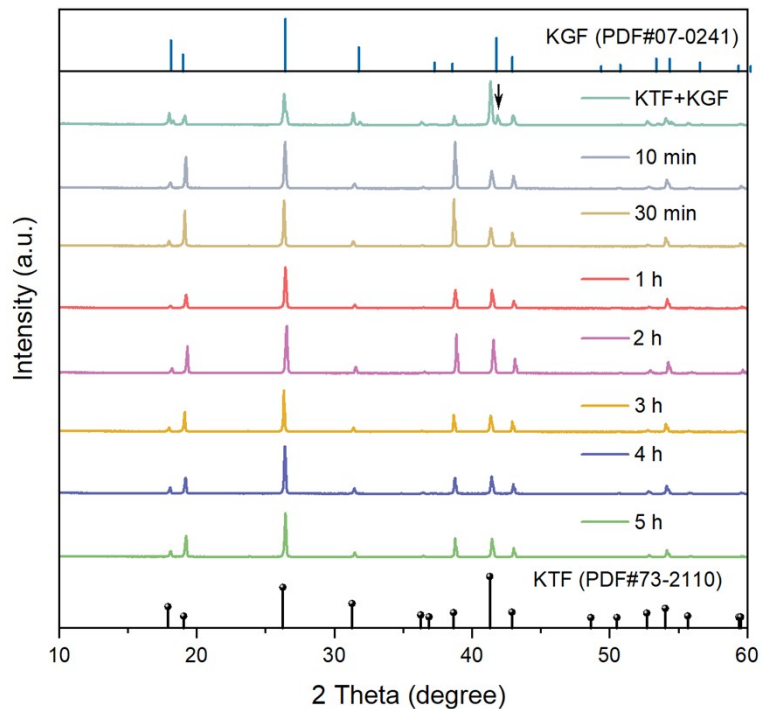


Fig. S2 XRD patterns of KTFM@KTGF synthesized for different reaction time (10 min, 30 min, 1 h, 2 h, 3 h, 4 h, 5 h).

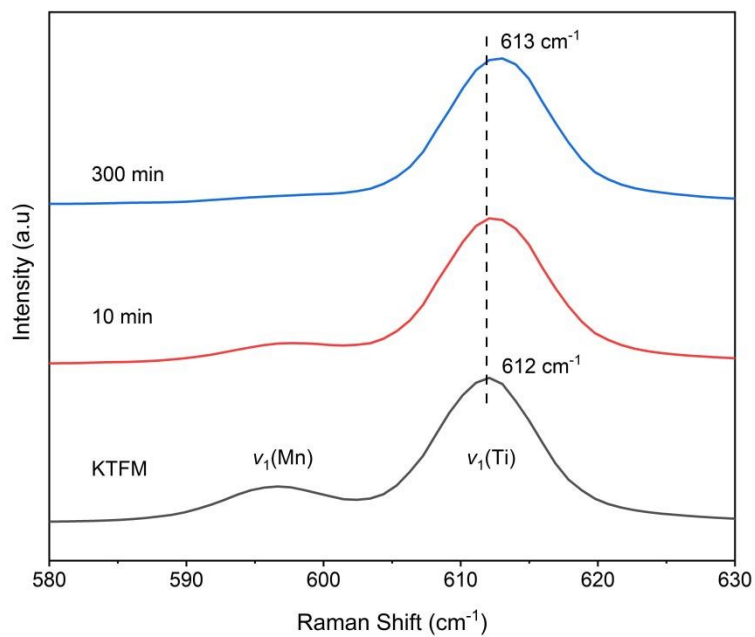


Fig. S3 Raman spectra of KTFM, KGFM and KTFM.

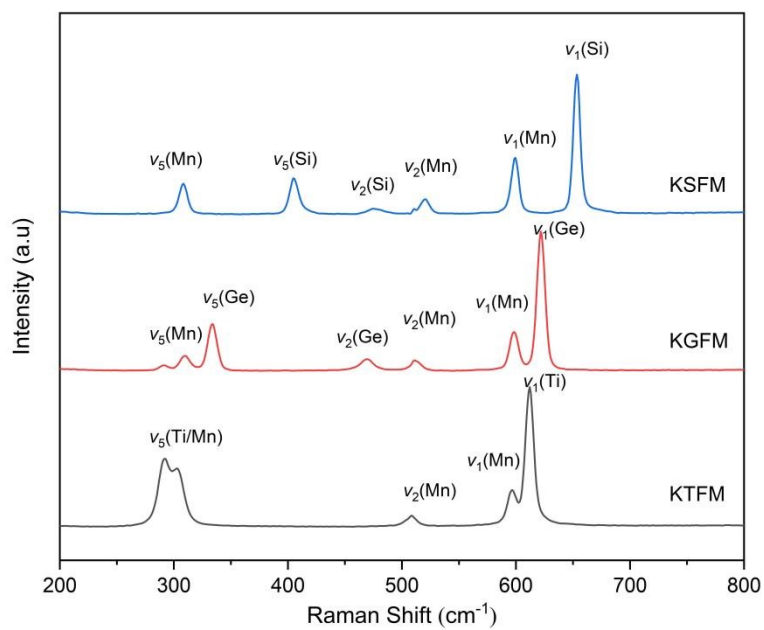


Fig. S4 Raman spectra of KTFM and KTFM@KTSF synthesized for different reaction time (10 min and 300 min).

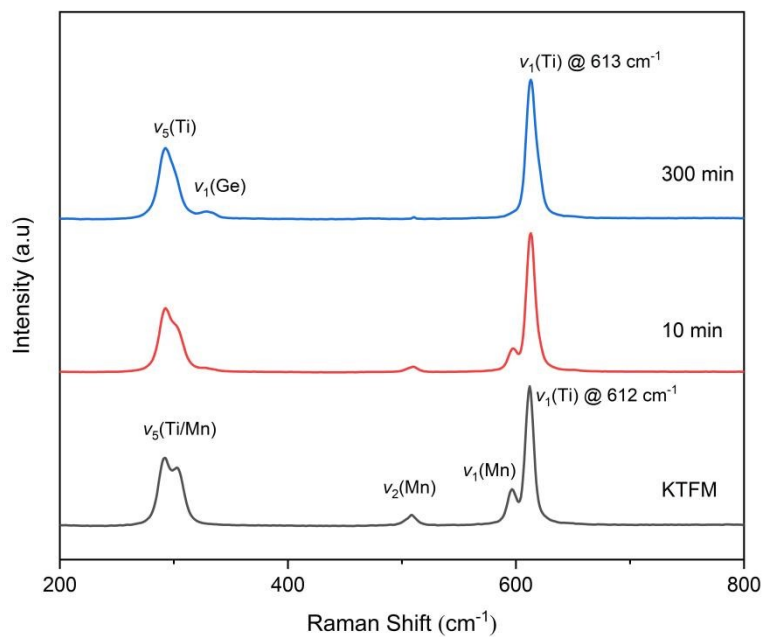


Fig. S5 Raman spectra of KTFM and KTFM@KTGF synthesized for different reaction time (10 min and 300 min).

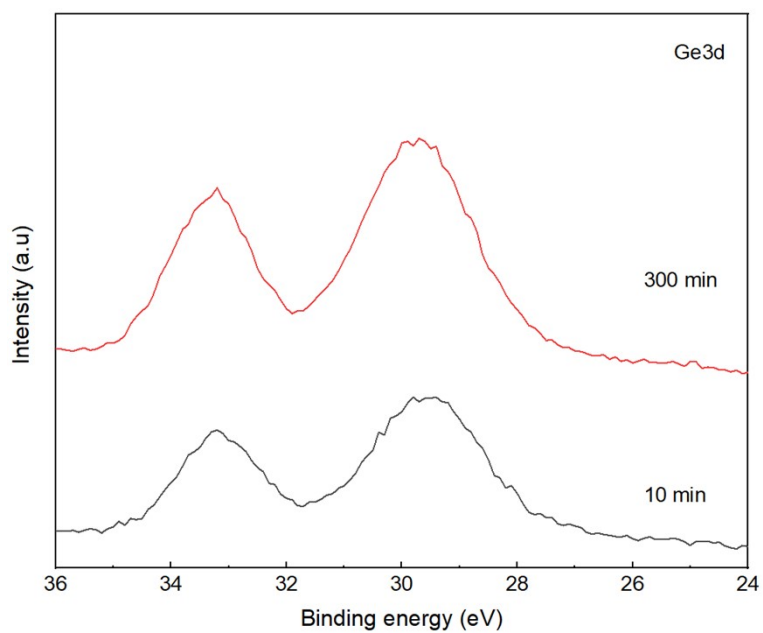


Fig. S6 Ge3d XPS spectra of KTFM@KTGF synthesized for different reaction time (10 min and 300 min).

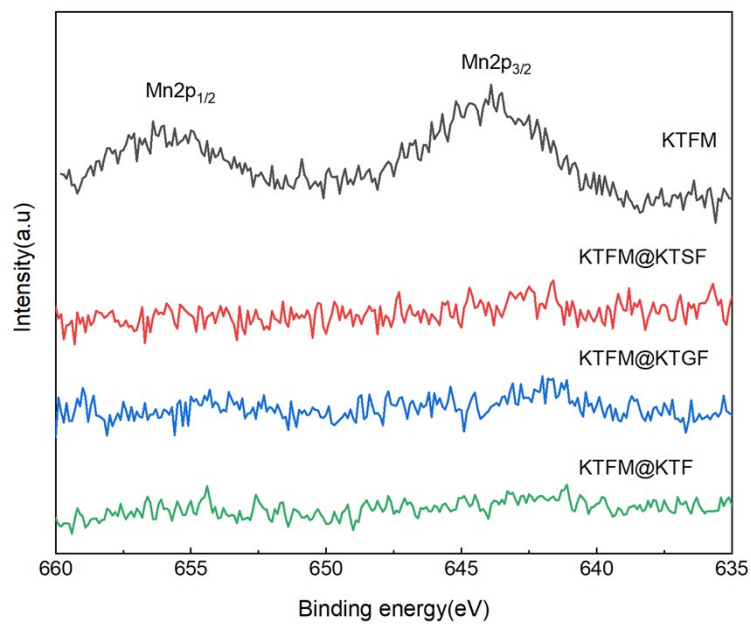


Fig. S7 Mn2p XPS spectra of KTFM, KTFM@KTSF, KTFM@KTGF and KTFM@KTF.

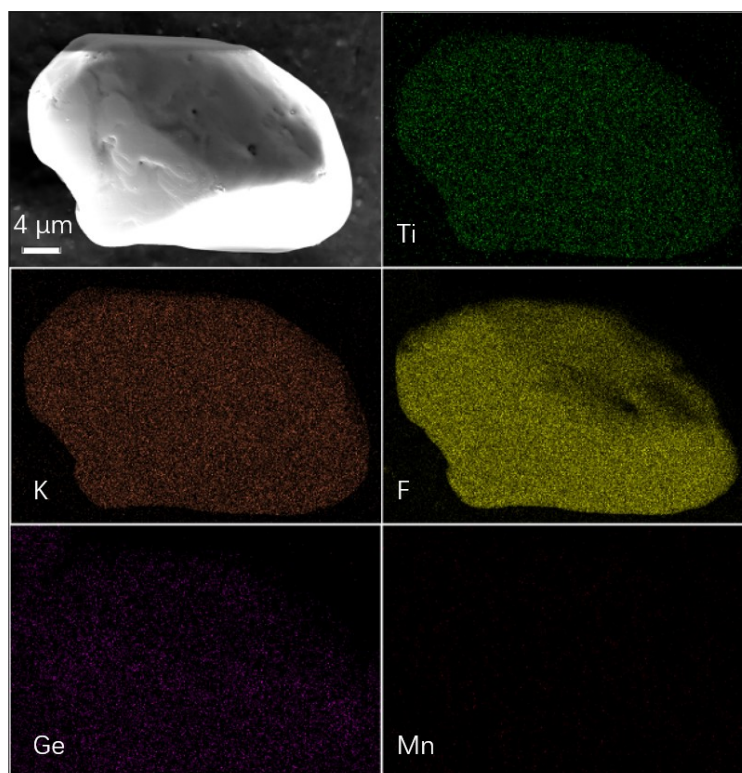


Fig. S8 SEM image and EDS of KTFM@KTGF.

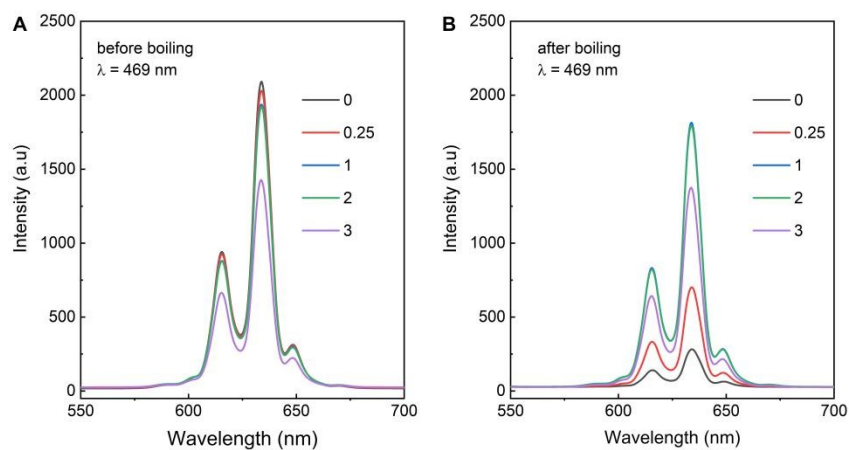


Fig. S9 PL spectra of as-prepared KTFM@KTSF samples using varied GA volume, (A) before boiling, (B) after boiling.

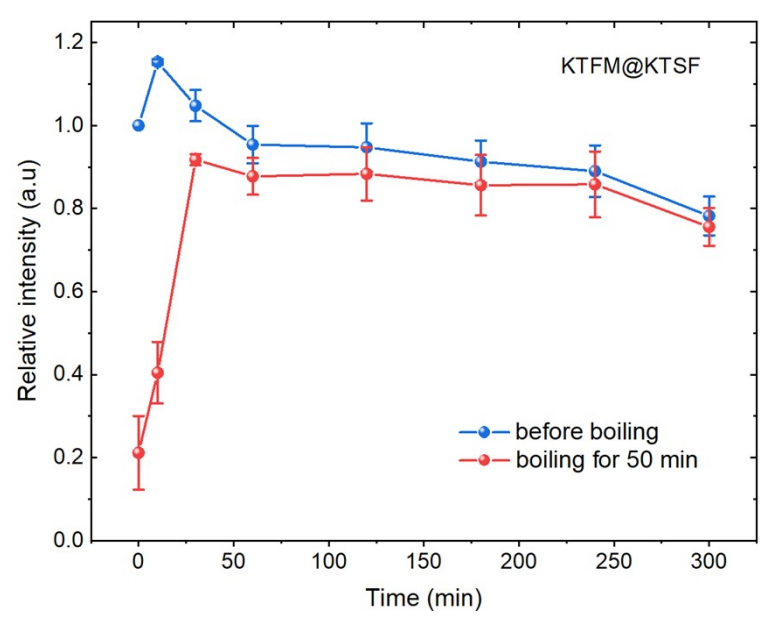


Fig. S10 Relative PL intensities of KTFM@KTSF as a function of reaction time, blue: before boiling, red: after boiling for 50 min.

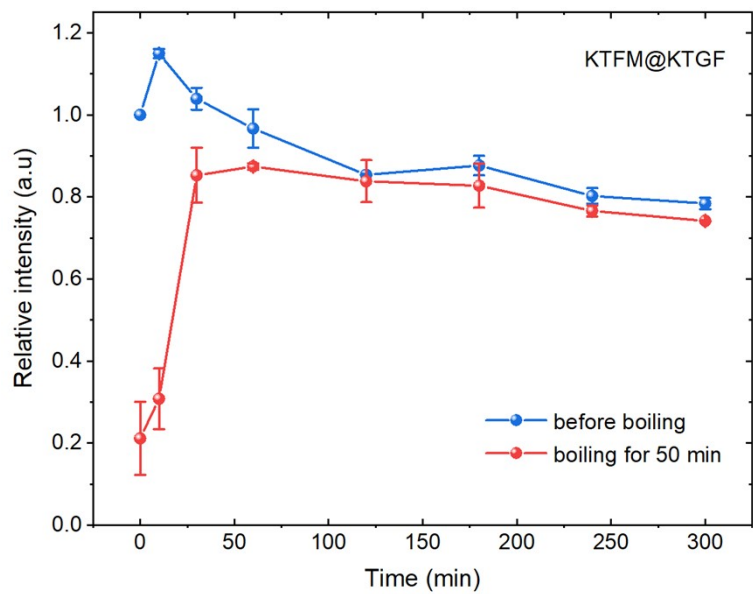


Fig. S11 Relative PL intensities of KTFM@KTGF as a function of reaction time, blue: before boiling, red: after boiling for 50 min.

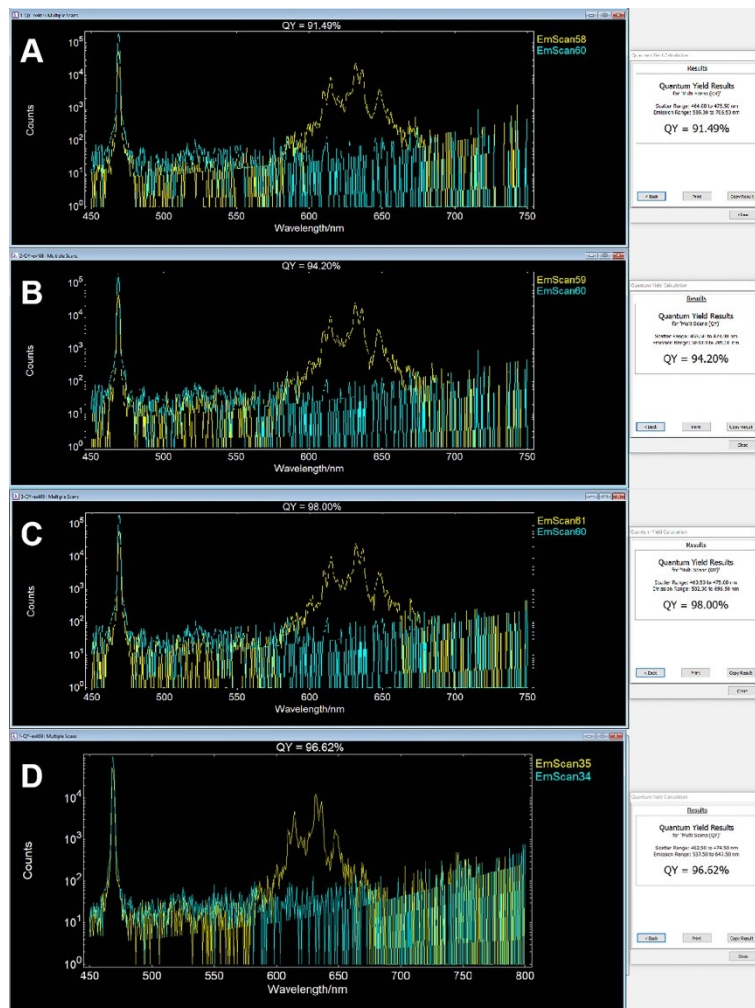


Fig. S12 Quantum efficiency results of four fluorides, (A) KTFM, (B) KTFM@KTSF, (C) KTFM@KTGF, (D) KTFM@KTF.

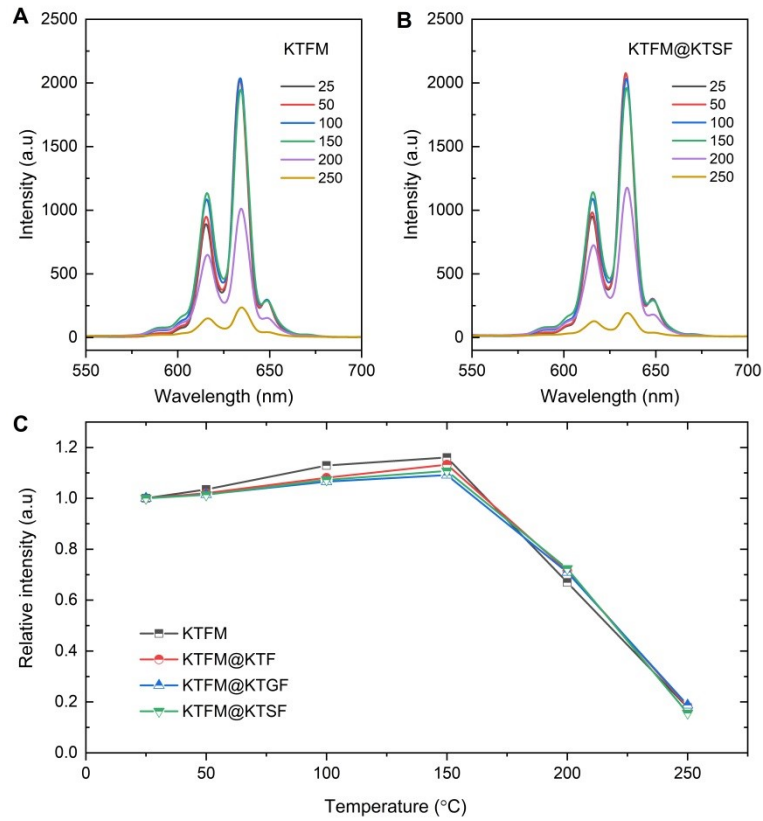


Fig. S13 Temperature-dependent PL spectra for (A) KTFM and (B) KTFM@KTSF. (C) Relative PL intensities of KTFM, KTFM@KTF, KTFM@KTGF and KTFM@KTSF samples as a function of temperature (25 -250 °C).

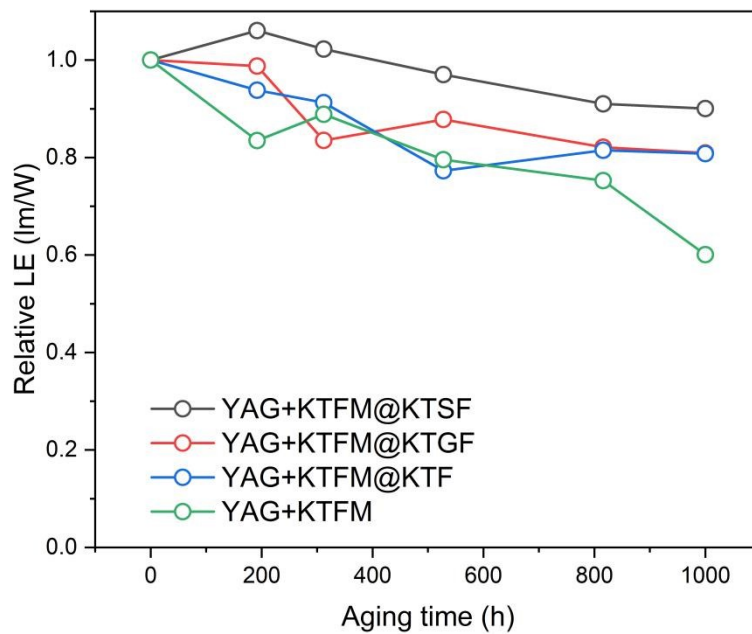


Fig. S14 Relative luminous efficacy of four WLEDs as function of aging time.

Table S1. Internal quantum efficiencies (IQE), Relative PL intensity after immersion in water of core-shell fluorides and aging performance of WLEDs using these red phosphors.

Sample	IQE	Relative PL intensity after immersion in water (%/h)	Relative LE of WLED@HTHH (%/h)	Ref.
$\text{K}_2\text{TiF}_6:\text{Mn}^{4+}@\text{K}_2\text{Ti}_{1-x}\text{Si}_x\text{F}_6$	94%	91%/360	90%/1000	This work
$\text{K}_2\text{TiF}_6:\text{Mn}^{4+}@\text{K}_2\text{Ti}_{1-x}\text{Ge}_x\text{F}_6$	98%	85%/360	81%/1000	This work
$\text{K}_2\text{TiF}_6:\text{Mn}^{4+}@\text{K}_2\text{TiF}_6$	93%	50%/300	89%/480	[1]
$\text{K}_2\text{SiF}_6:\text{Mn}^{4+}@\text{K}_2\text{SiF}_6$	76%	82%/4		[2]
$\text{K}_2\text{SiF}_6:\text{Mn}^{4+}@\text{PA}$	99%	88.5%/360		[3]
KSFM-RSRC	98%	94%/360	89%/500	[4]
$\text{K}_2\text{TiF}_6:\text{Mn}^{4+}$ with surface passivation using H_2O_2	83%	97%/12	39%/2400	[5]
$\text{K}_2\text{TiF}_6:\text{Mn}^{4+}/\text{CaF}_2$	79%	86.4%/2		[6]

References

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