Supporting Information

Insoluble oxalates modified $K_2XF_6:Mn^{4+}$ (X = Ti, Ge, Si) red-emitting phosphors exhibiting excellent moisture resistance and luminescence for warm white light-emitting diodes

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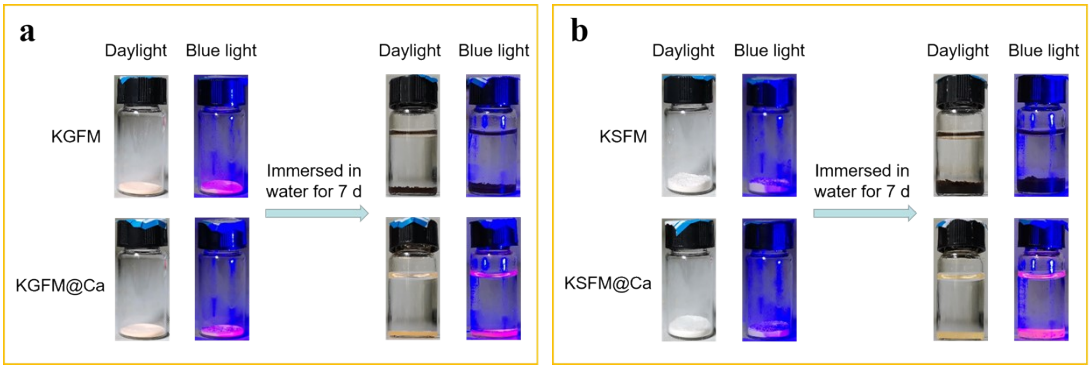

Fig. S1 Photographs of (a) KGFM and KGFM@Ca, (b) KSFM and KSFM@Ca in air and water.

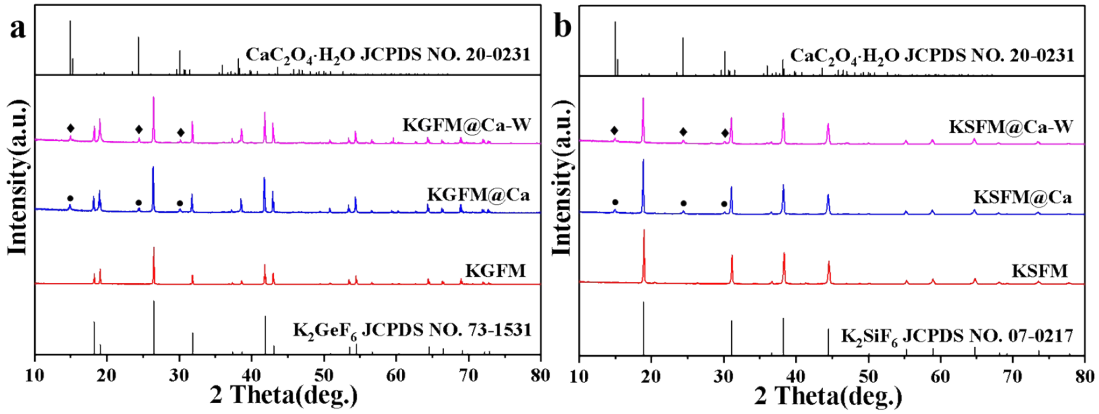

Fig. S2 (a) XRD patterns of KGFM, KGFM@Ca and KGFM@Ca-W; (b) XRD patterns of KSFM, KSFM@Ca and KSFM@Ca-W.

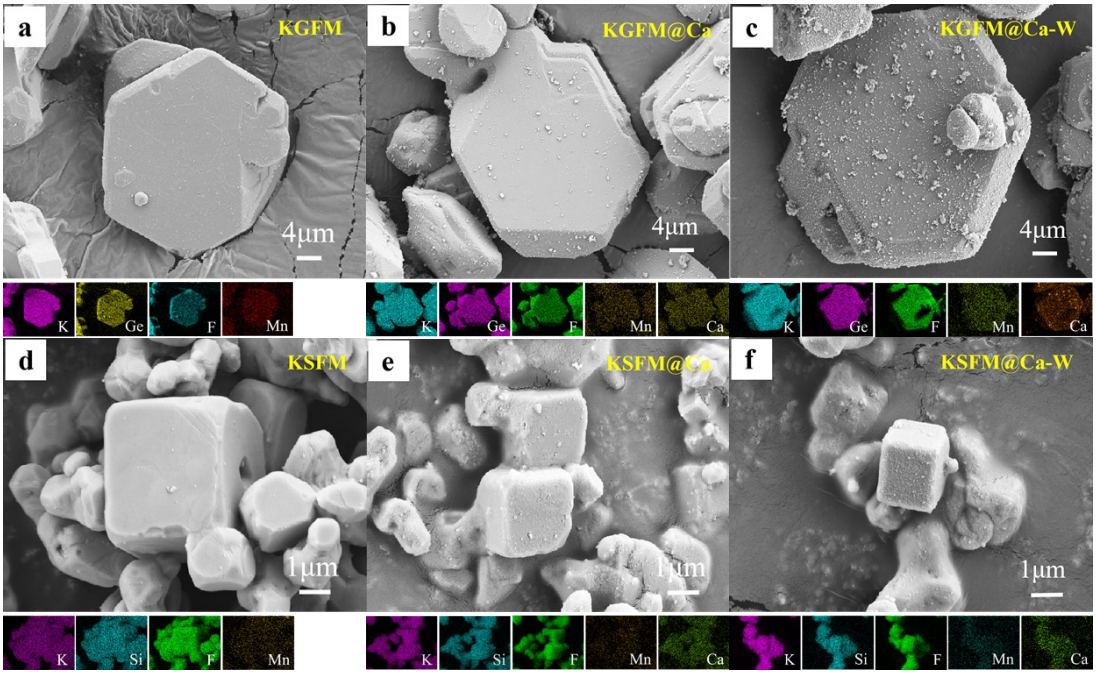

Fig. S3 (a)-(c) SEM and EDS mapping images of KGFM, KGFM@Ca and KGFM@Ca-W; (d)-(f) SEM and EDS mapping images of KSFM, KSFM@Ca and KSFM@Ca-W.

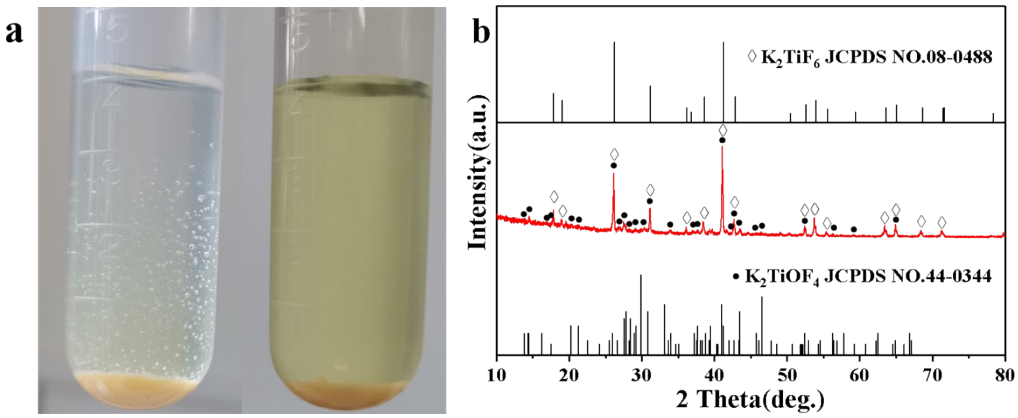

Fig. S4 (a) Photographs of KTFM@Ca-W immersed in water for different times (Left: incipient, Right: 7 days); (b) XRD patterns of the products evaporated from yellowish solution.

Table S1 ICP results of KTFM@Ca and KTFM@Ca-W phosphors

Samples	C_{Mn} [mol%]	C_{Ti} [mol%]	C_{Ca} [mol%]
KTFM@Ca	2.82	57.04	40.14
KTFM@Ca-W	2.04	58.23	39.73

Table S2 The key optoelectronic parameters of devices operated at 3.2 V and 320 mA

Devices	Yellow / red phosphor ratio	Chromaticity coordinates	LE (lm/W)	CCT (K)	R_a
LED-0	1:0	(0.3349, 0.3604)	100.4	5410	72.0
LED-1	1:1	(0.3530, 0.3825)	87.9	4838	77.3
LED-2	1:2	(0.3738, 0.3909)	79.0	4275	81.7
LED-3	1:3	(0.3847, 0.3934)	74.3	4007	85.4

Table S3 The key optoelectronic parameters of LED-2 operated at various currents

Current (mA)	Chromaticity coordinates	LE (lm/W)	CCT (K)	Ra
40	(0.3800, 0.4020)	120.5	4179	83.0
80	(0.3788, 0.3996)	112.3	4195	82.7
120	(0.3777, 0.3977)	104.9	4213	82.4
160	(0.3764, 0.3964)	98.2	4238	82.2
200	(0.3760, 0.3952)	92.5	4241	82.0
240	(0.3753, 0.3937)	87.6	4250	81.9
280	(0.3745, 0.3923)	83.1	4265	81.8
320	(0.3738, 0.3909)	79.0	4275	81.7