

Supporting Information

Synthesis of $\text{Na}_2\text{SiF}_6:\text{Mn}^{4+}$ red phosphors for white LED applications by co-precipitation

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1. Preparation of $\text{Na}_2\text{SiF}_6:\text{Mn}^{4+}$ (NSFM-1S) via the one-step method

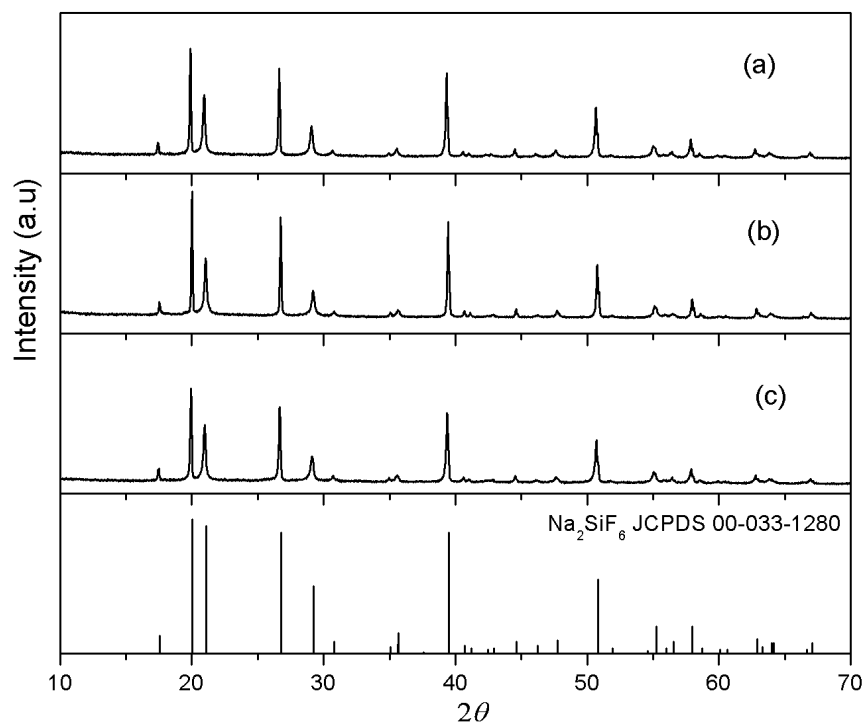


Figure S1. XRD patterns of NSFM-1S prepared using saturated solution of (a) Na_2CO_3 , (b) Na_2SO_4 and (c) NaOH .

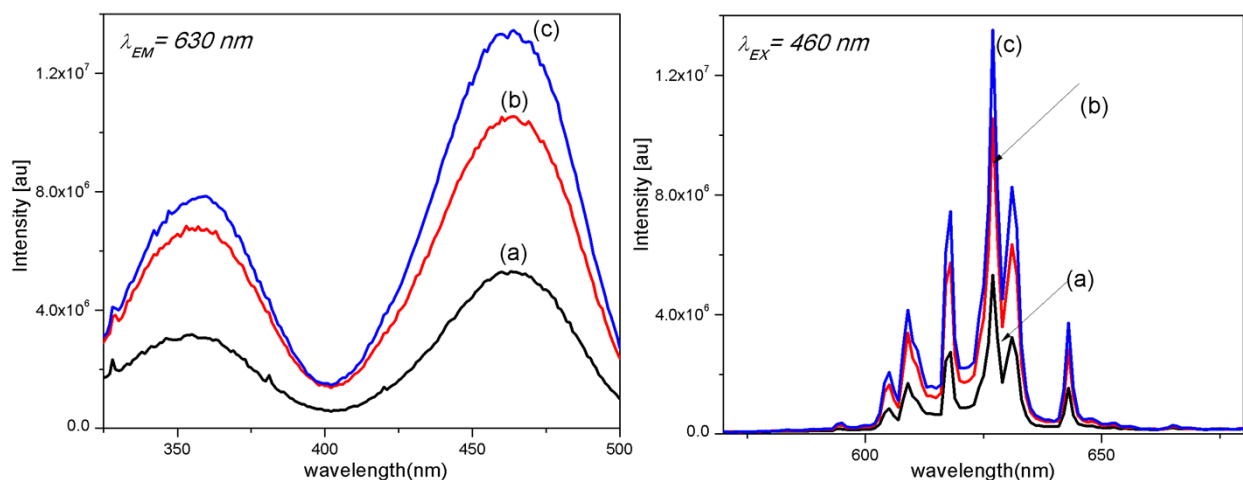


Figure S2. PLE and PL spectra of NSFMs prepared using saturated solution of (a) Na_2CO_3 , (b) Na_2SO_4 and (c) NaOH .

2. Preparation of $\text{K}_2\text{SiF}_6:\text{Mn}^{4+}$ (KSFMs) via the one-step method

The SiO_2 powders (1.2 g) were dissolved in 25 mL solution of HF 48% at 60 °C for 2 h to form silicon fluoride solution. The solution was cooled to room temperature and separated from residual powder by using filter paper. 0.23 g KMnO_4 was added to the filtered solution to obtain solution A. Thereafter, another mixture of 3.4 g KF dissolved in solution of 15 ml HF 48% and 0.15 ml H_2O_2 (35–40%) was added to the solution A under vigorous stirring. The deep purple solution turned to yellow rapidly. The yellow powder was obtained as 100 ml acetone (99.9%) was poured into the resulting solution. The powder was dried at 70 °C after washing with solution HF 20% for removing undesired products and residual chemicals, and then with ethanol (99.9%) for several times.

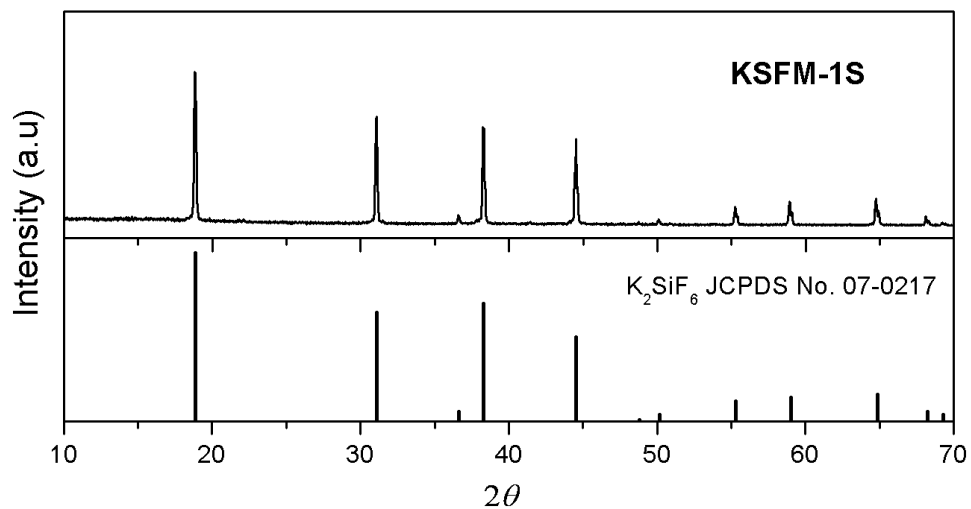


Figure S3. XRD diffraction pattern of KSFM-1S.

In Figure S3, the X-ray diffraction pattern of prepared KSFM-1S shows all diffracted peaks corresponding to space group $Fm\bar{3}m$ of cubic K_2SiF_6 (JCPDS No. 07–0217).

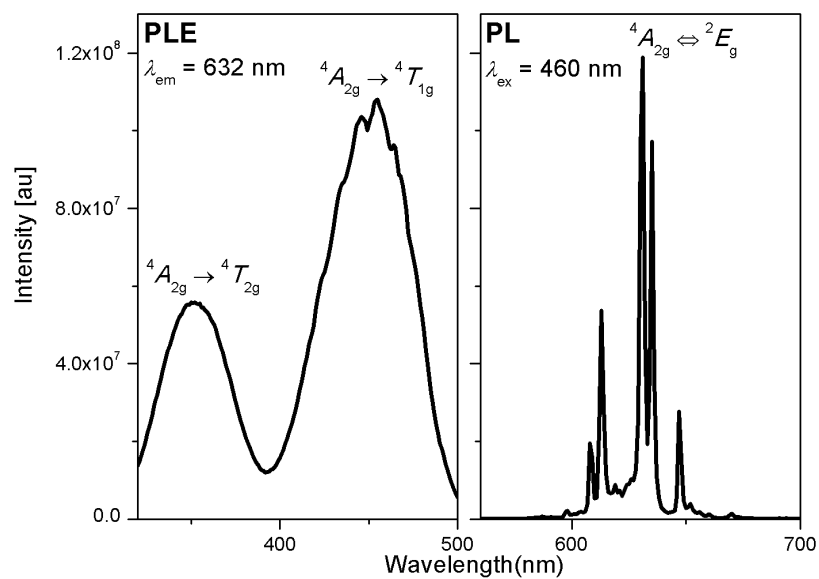


Figure S4. PLE and PL spectra of KSFM-1S.

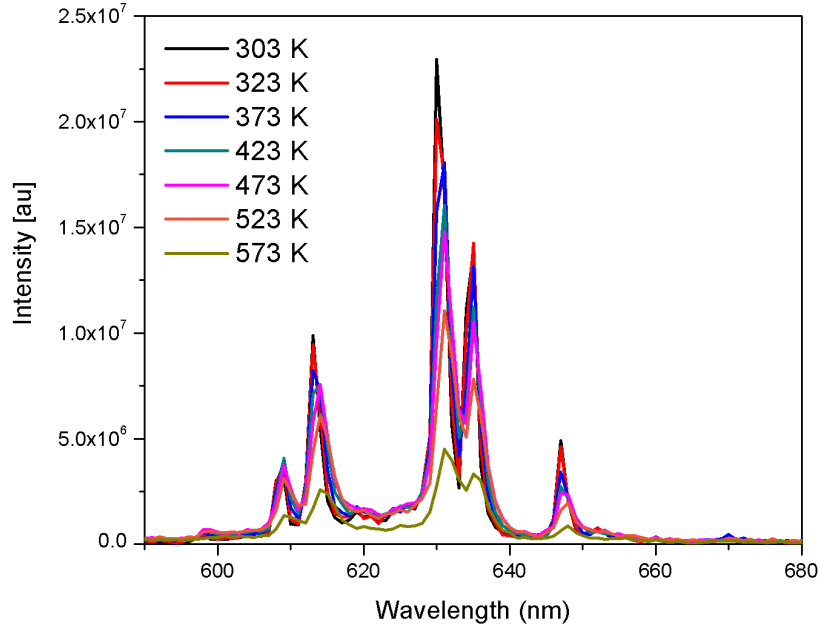


Figure S5. Temperature-dependent emission spectra of KSFM-1S.

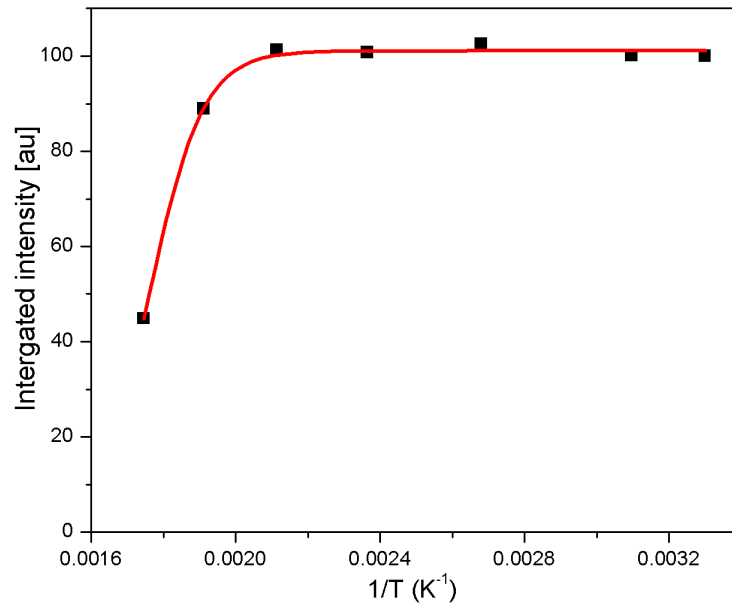


Figure S6. Integrated red PL intensity for the KSFM-1S.

The temperature-dependent behavior of integrated PL intensity (I_{PL}/I_{PL303}) (Fig. S6) shows considerable stability for KSFM-1S red phosphor in the temperature range of 303–423 K. At 432 K, the relative PL intensity remains 100% of that at 303 K, showing clearly an excellent thermal stability of KSFM-1S phosphor. The integrated PL intensity for KSFM-1S can be fitted by I_T/I_0

$= [1 + D \exp(-E_a/kT)]^{-1}$, where I_0 is intensity at $T = 0$ K, D and activation energy E_a are refined variables. The activation energies obtained for KSFM-1S red phosphor is 1.09 eV.

3. Preparation of K_2MnF_6

The yellow powder K_2MnF_6 was precipitated by slowly dropping H_2O_2 into mixture of $KMnO_4$ and KHF_2 (weight ratio of 1:20) dissolved in 48% HF solution.

All x-ray diffracted peaks of prepared K_2MnF_6 can be indexed to space group $P63mc$ of hexagonal K_2MnF_6 (JCPDS No. 77-2133), as shown Figure S7.

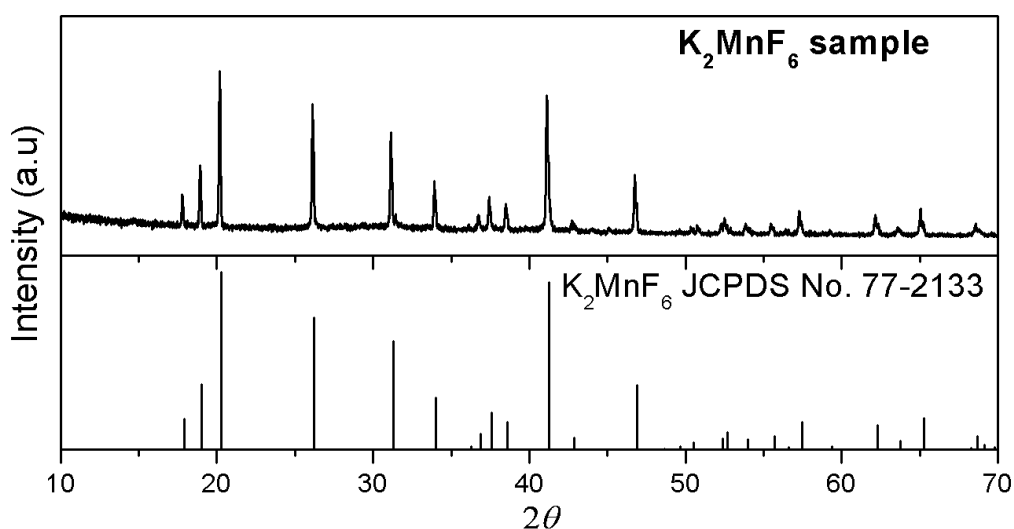


Figure S7. XRD diffraction pattern of K_2MnF_6 .

4. The chromaticity coordinate of the fabricated WLED

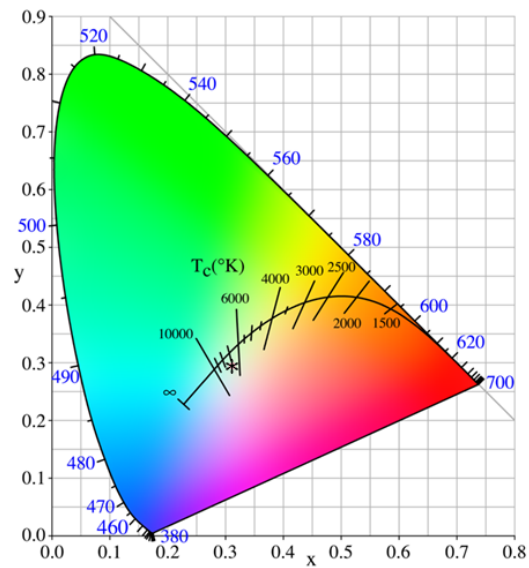


Figure S8. The chromaticity coordinate (*) of the WLED (fabricated by combining commercial YAG:Ce yellow phosphor, NSFM-2S red phosphor and blue-LED chip) with correlated color temperature of 6875 K in Commission Internationale de l'Éclairage (CIE) 1931 color spaces.