

Electronic Supplementary Information (ESI)

Upconversion luminescence and temperature sensing characteristics

of  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.5}(\text{WO}_4)_3:\text{Er}^{3+}/\text{Yb}^{3+}$  phosphors

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**Table S1** Crystallographic data for  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.425}\text{Yb}_x\text{Er}_y(\text{WO}_4)_3$  and  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.5-x-y}\text{Yb}_x\text{Er}_y(\text{WO}_4)_3$  (sp. gr.  $R\bar{3}c$ ,  $Z = 6$ )

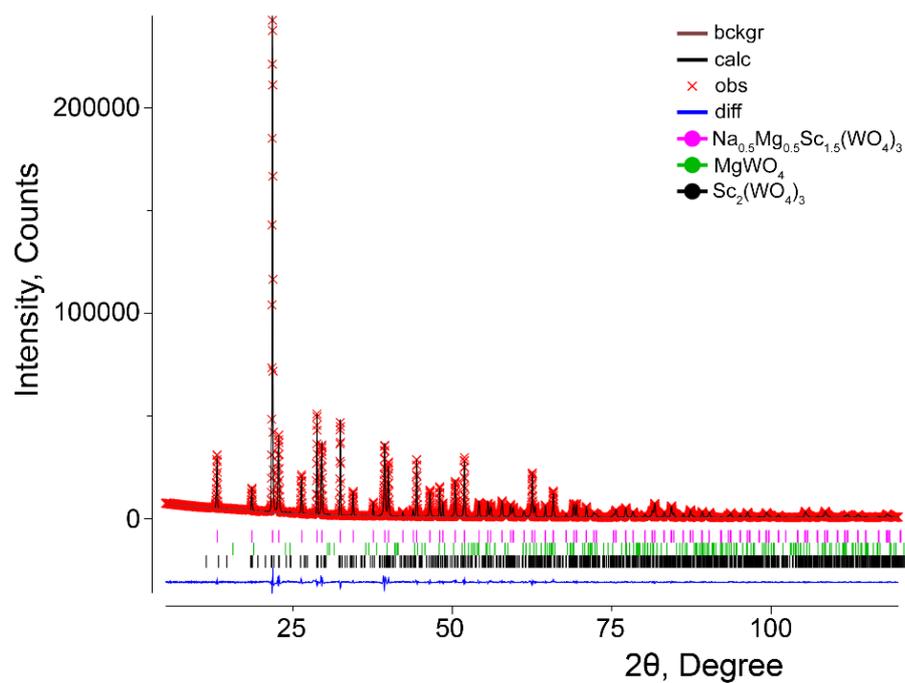
$x, y$	$a, \text{Å}$	$c, \text{Å}$	$V, \text{Å}^3$
$\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.425}\text{Yb}_x\text{Er}_y(\text{WO}_4)_3$			
$x = 0.0675, y = 0.0075$	9.5672(4)	23.5931(10)	1870.19(17)
$x = 0.060, y = 0.015$	9.5669(4)	23.6344(9)	1873.34(14)
$x = 0.0525, y = 0.0225$	9.5654(4)	23.6767(9)	1876.11(16)
$x = 0.045, y = 0.030$	9.5652(5)	23.7029(14)	1878.14(22)
$x = 0.0375, y = 0.0375$	9.5643(3)	23.7193(11)	1879.05(16)
$\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.5-x-y}\text{Yb}_x\text{Er}_y(\text{WO}_4)_3$			
$x = 0.030, y = 0.020$	9.5662(8)	23.4929(22)	1861.85(37)
$x = 0.015, y = 0.010$	9.5674(4)	23.4792(15)	1861.22(20)

**Table S2** Selected interatomic distances (Å) for  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.5}(\text{WO}_4)_3$

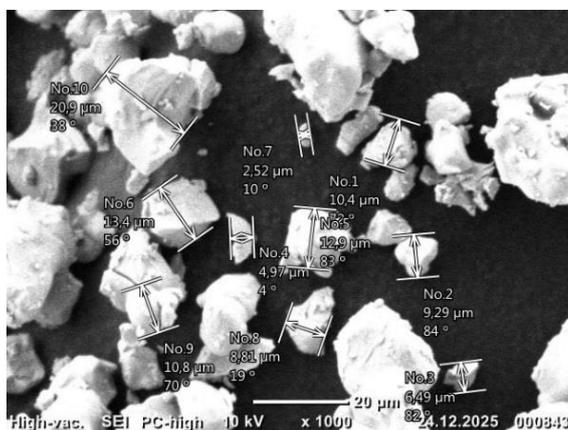
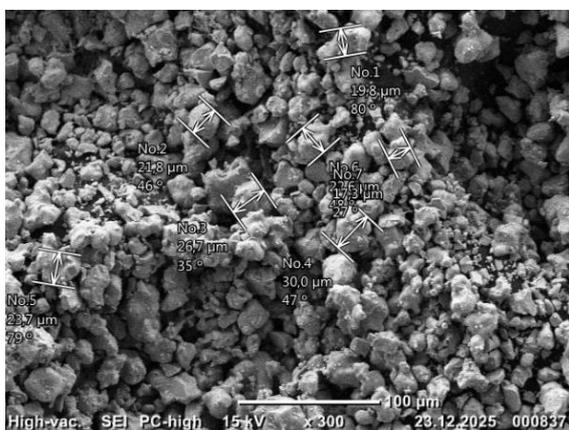
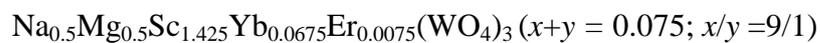
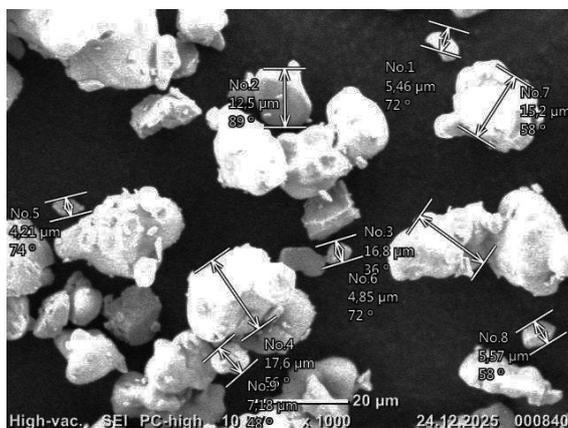
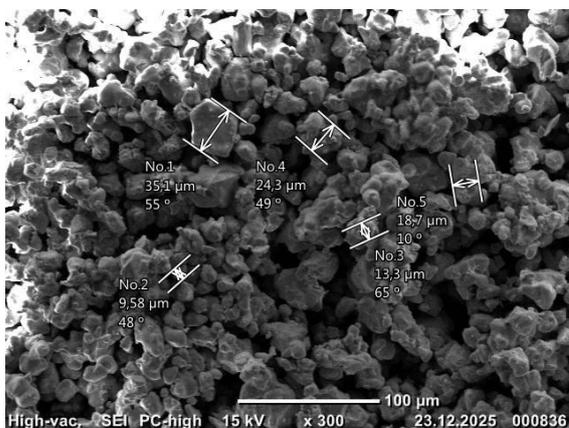
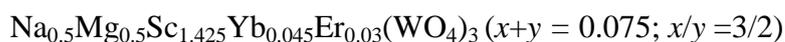
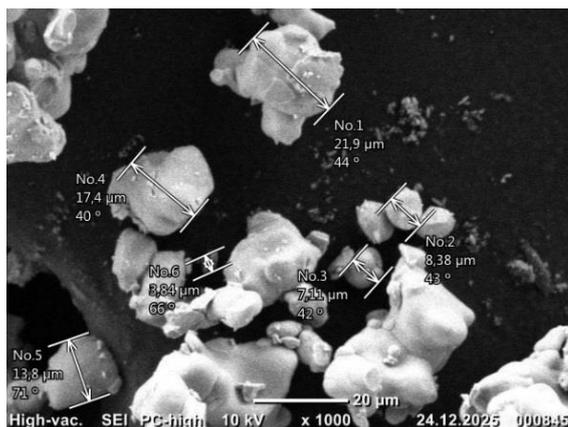
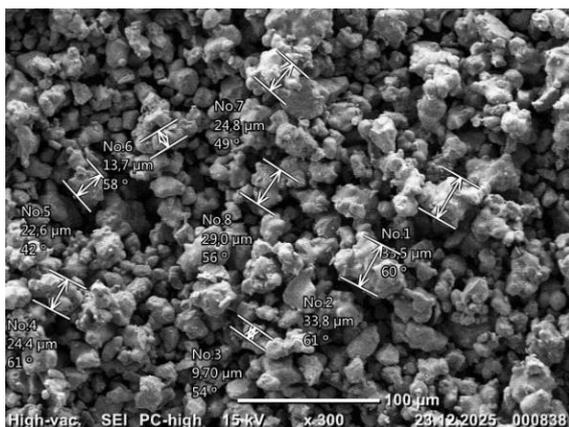
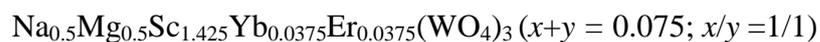
Interatomic distances		
W–O(1)	2×	1.763(5)
W–O(2)	2×	1.767(8)
<b>W–O<sup>a</sup></b>		<b>1.765</b>
<i>Expected<sup>b</sup></i>		<i>1.775</i>
Mg/Sc–O(1)	3×	2.053(8)
Mg/Sc–O(2)	3×	2.074(7)
<b>Mg/Sc–O<sup>a</sup></b>		<b>2.064</b>
<i>Expected<sup>b</sup></i>		<i>2.094</i>
Na–O(1)	6×	2.669(9)
<b>Na–O<sup>a</sup></b>		<b>2.669</b>
<i>Expected<sup>b</sup></i>		<i>2.380</i>

<sup>a</sup> The average values are given in boldface.

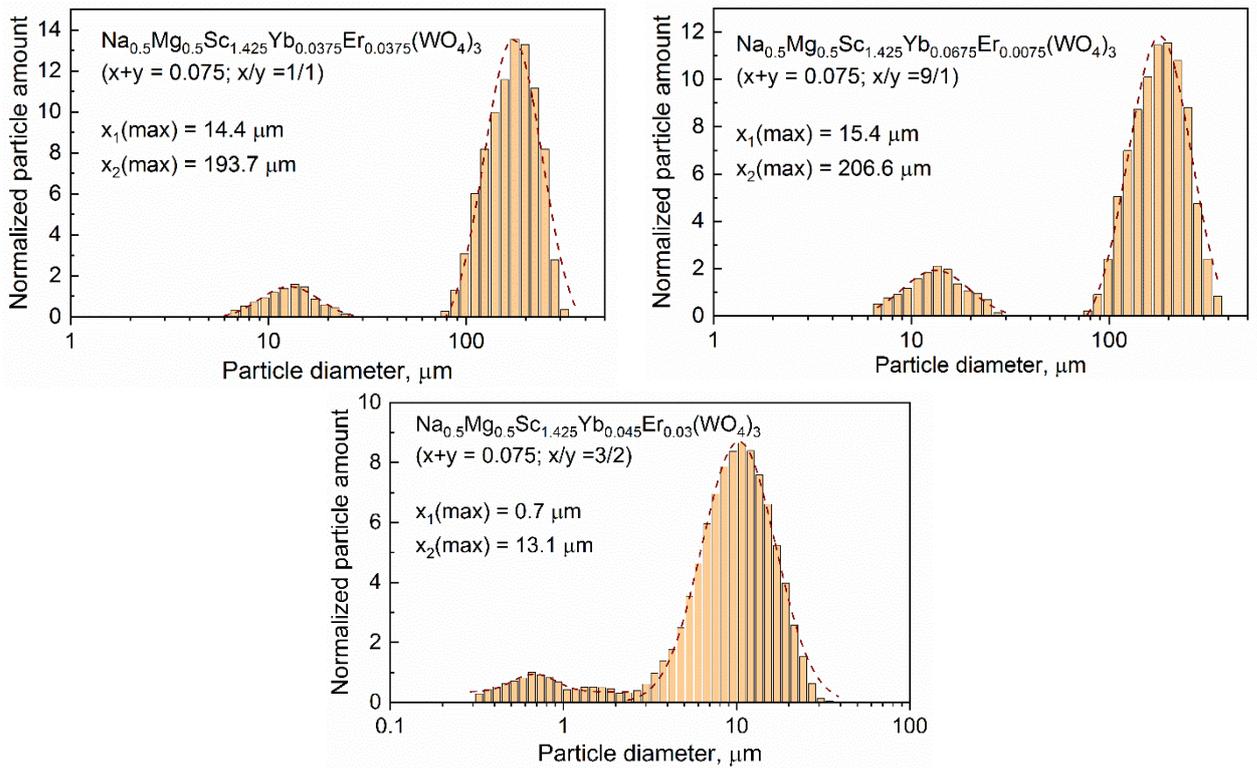
<sup>b</sup> The expected values were calculated as the sum of crystal radii according to Ref. [R. D. Shannon, Revised effective ionic radii and systematic studies of interatomic distances in halides and chalcogenides, *Acta Crystallogr., Sect. A: Cryst. Phys., Diffr., Theor. Gen. Crystallogr.* 1976, **32**, 751–767]:  $\text{W}^{+6}$  (IV) – 0.56 Å,  $\text{Mg}^{+2}$  (VI) – 0.860 Å,  $\text{Sc}^{+3}$  (VI) – 0.885 Å,  $\text{Na}^{+1}$  (VI) – 1.16 Å,  $\text{O}^{-2}$  (III) – 1.22 Å,  $\text{O}^{-2}$  (II) – 1.21 Å.



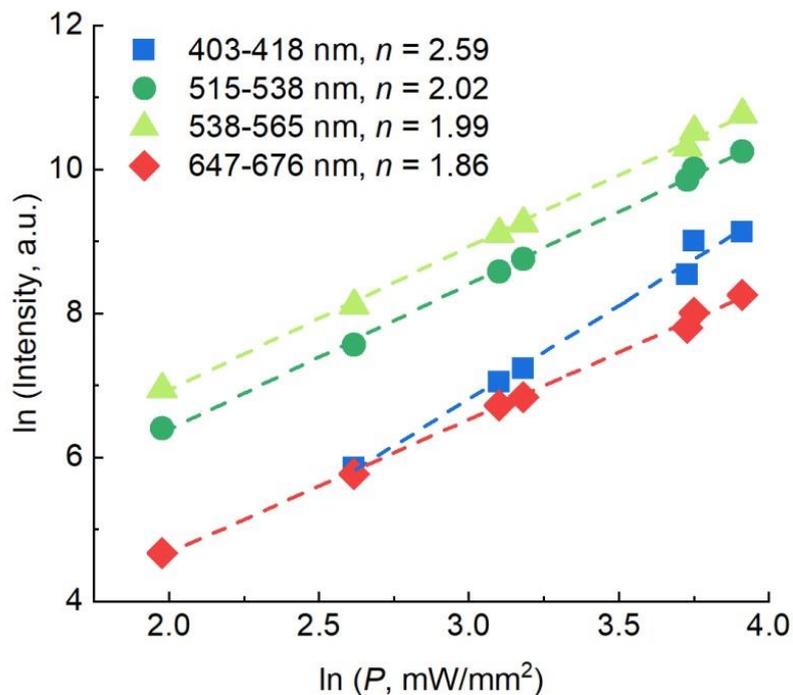
**Fig. S1** Experimental (crosses), calculated (solid line), and difference (bottom line) XRPD patterns for  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.5}(\text{WO}_4)_3$ . Series of tick marks correspond to the Bragg reflections: Phase 1 -  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.5}(\text{WO}_4)_3$ , Phase 2 – 0.8 m.%  $\text{MgWO}_4$ , Phase 3 – 1.3 m.%  $\text{Sc}_2(\text{WO}_4)_3$ .



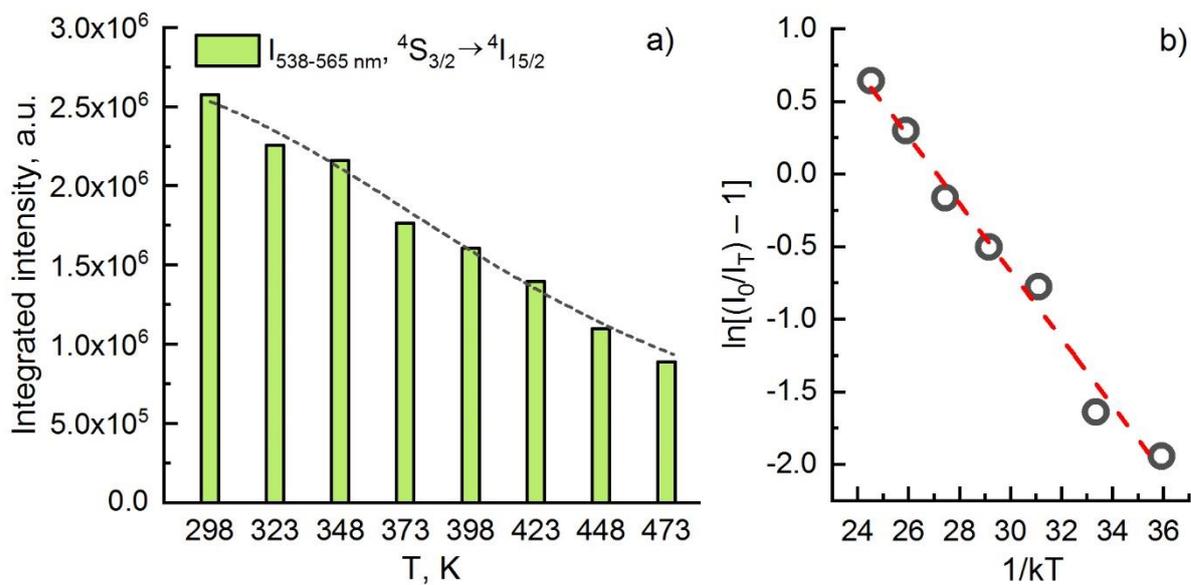
**Fig. S2** SEM images of  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.425}\text{Yb}_x\text{Er}_y(\text{WO}_4)_3$  ( $x/y = 9/1, 3/2$  or  $1/1$ ) powders



**Fig. S3** Particle size distribution histograms for  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.425}\text{Yb}_x\text{Er}_y(\text{WO}_4)_3$  powders,  $x/y = 9/1, 3/2$  or  $1/1$



**Fig. S4** Power dependence of the luminescence intensity for  $\text{Na}_{0.5}\text{Mg}_{0.5}\text{Sc}_{1.45}\text{Yb}_{0.03}\text{Er}_{0.02}(\text{WO}_4)_3$  in the low-power regime. The data for 403-418 nm emission were collected at a fourfold increase in the width of the entrance slit.



**Fig. S5** The influence of temperature on the integrated intensity of the lines at 538-565 nm (a) and the corresponding dependence of  $\ln[(I_0/I_T) - 1]$  on  $1/kT$  (b). The line through the data points is fitted according to the modified Arrhenius equation.