Supplementary Information

NASICON-type $Na_{3.6}Lu_{1.8-x}(PO_4)_3$:$xEu^{3+}$ phosphors: structure and luminescence

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Table S1. Element analysis results of $Na_{3.6}Lu_{1.8-x}(PO_4)_3$:$xEu^{3+}$ (x = 0, 0.3).

NLPO:xEu	P, at.%	Lu, at.%	Eu, at.%	P:Lu:Eu ratio
x = 0	63.81±0.45	36.19±0.45	-	3:1.70(3):0
x = 0.30	62.99±0.57	31.07±0.35	5.94±0.23	3:1.48(4):0.28(2)

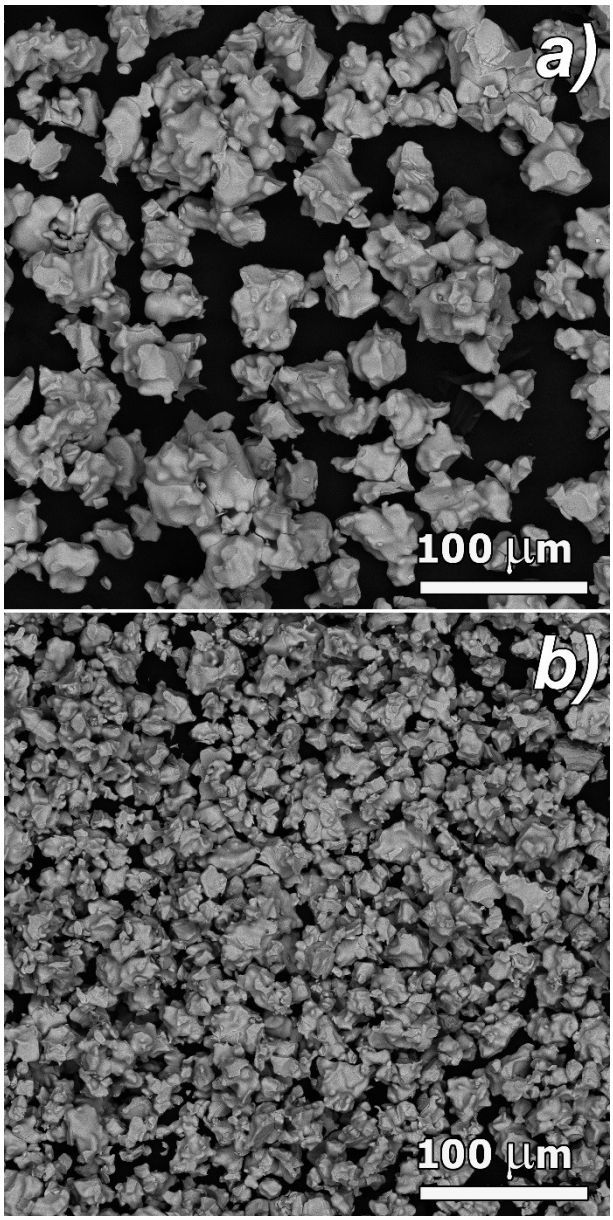

Figure S1. SEM images of $Na_{3.6}Lu_{1.8-x}(PO_4)_3$:$xEu^{3+}$ (x = 0 (a), 0.3 (b)).

Table S2. The unit cell parameters for $Na_{3.6}Lu_{1.8-x}(PO_4)_3$:$xEu^{3+}$.

x	a, Å	c, Å	V, Å^3
0.05	9.1050(2)	22.2467(6)	1597.17(6)
0.1	9.1080(3)	22.2086(1)	1595.51(7)
0.3	9.1176(2)	22.1982(7)	1598.12(7)
0.4	9.1208(2)	22.1803(6)	1597.94(6)
0.45	9.1216(1)	22.1409(4)	1595.39(5)
0.5	9.1259(2)	22.1473(8)	1597.37(8)
0.6	9.1263(2)	22.1375(8)	1596.80(8)
0.7	9.1335(1)	22.1481(9)	1600.08(5)

Table S3. Atomic coordinates, isotropic displacement atomic parameters (U_{iso}), site occupation of $Na_{3.6}Lu_{1.8}(PO_4)_3$ and anisotropic temperature factors (U_{ij} in Å^2) of the Lu site.

Position	x	y	z	U_{iso}*100, Å^2	Occupancy	
Lu	0	0	0.15551(8)	1.22(5)	0.950(9)Lu	
Na4	0	0	0.15551(8)	0.00(1)	0.050(9)Na	
Na1	0.138(3)	0.077(5)	0.0232(10)	0.26(12)	0.268(11)Na^+	
Na2	0.6655(16)	0	0.25	0.32(9)	0.453(8)Na^+	
Na3	0	0	0.25	0.9(2)	0.53(3)Na^+	
P1	0.2959(7)	0	0.25	0.9(2)	1P	
O1	0.214(1)	-0.0207(9)	0.1825(5)	0.7(2)	1O	
O2	0.1996(10)	0.1762(11)	0.0966(5)	0.7(2)	1O	
	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Lu	0.0023(5)	0.0023(5)	0.032(1)	0.0011(3)	0	0

Table S4. Selected bond lengths (Å) and angles (◦) for $Na_{3.6}Lu_{1.8}(PO_4)_3$.

Polyhedron	Distance	d, Å	Polyhedron	Distance	d, Å
$Na1O_6$	Na1-O1	2.46(6)	**$Na2O_8$**	Na2-O1×2	2.428(4)
	Na1-O1	3.06(5)		Na2-O1×2	2.946(9)
	Na1-O2	1.82(3)		Na2-O2×2	2.472(11)
	Na1-O2	2.74(4)		Na2-O2×2	2.828(18)
	Na1-O2	2.91(3)		<Na2-O>	2.669
	Na1-O2	3.12(3)	**PO_4**	P-O1×2	1.651(2)
				P-O1×2	1.529(8)
	<Na1-O>	2.69		<P-O>	1.590

(Lu/Na4)O_6 - *octahedron*						
Lu/Na4	O1	O1	O1	O2	O2	O2
O1	2.1372(5)	112.40(4)	112.40(4)	76.8(3)	78.9(3)	158.9(3)
O1		2.1372(5)	112.40(4)	78.9(3)	158.9(3)	76.8(3)
O1			2.1372(5)	158.9(3)	76.8(3)	78.9(3)
O2				2.166(9)	87.0(4)	87.0(4)
O2					2.166(9)	87.0(4)
O2						2.166(9)
<(Lu/Na4)-O>	2.1516					
Na3O_6- polyhedron						
Na3	O1	O1	O1	O1	O1	O1
O1	2.545(3)	88.5(3)	88.5(3)	73.14(4)	125.6(4)	139.5(4)
O1		2.545(3)	88.5(3)	139.5(4)	73.14(4)	125.6(4)
O1			2.545(3)	125.6(4)	139.5(4)	73.14(4)
O1				2.545(3)	88.5(3)	88.5(3)
O1					2.545(3)	88.5(3)
O1						2.545(3)

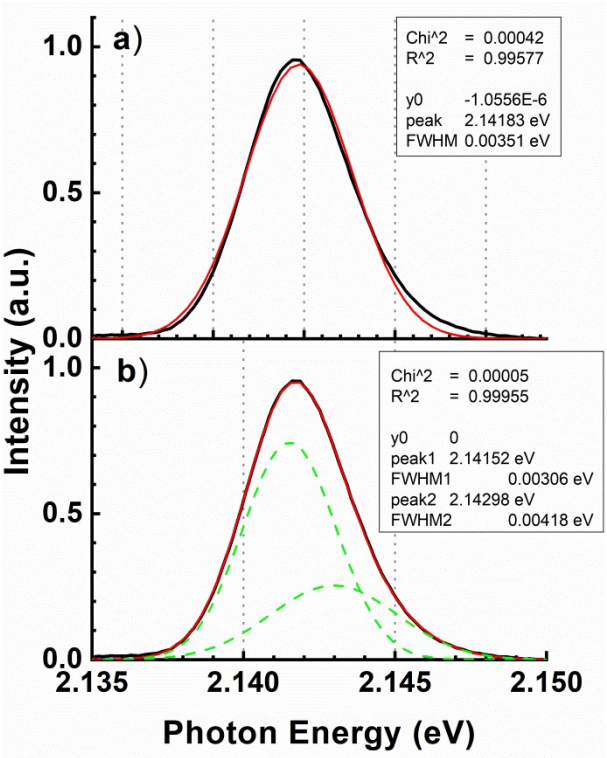

Figure S2. Fitting of the peak 2.141 eV (579 nm, $^5D_0 \rightarrow {}^7F_0$ transitions) of $Na_{3.6}Lu_{1.3}(PO_4)_3$:0.5Eu^{3+} with single (a) and two (b) Gaussian functions.