Electronic Supplementary Information for

Efficient Bi^{3+} to Eu^{3+} energy transfer and color tunable emissions in $K_7CaY_2(B_5O_{10})_3$-based phosphors

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Table S1. Selected bond distances for $K_7CaEu_2(B_5O_{10})_3$ from Rietveld refinements

Bond	Length (Å)	Bond	Length (Å)
Ca1/Eu1-O4 (×4)	2.439(7)	**<M1-O>**	**2.439(7)**
Ca1/Eu1-O4 (×2)	2.440(7)		
Ca2/Eu2-O1 (×3)	2.313(7)	**<M2-O>**	**2.354(7)**
Ca2/Eu2-O4 (×3)	2.394(7)		
K1-O1 (×2)	2.790(7)	**<K1-O>**	**2.928(5)**
K1-O3 (×2)	2.897(1)		
K1-O2 (×2)	3.098(8)		
K2-O5 (×2)	2.763(1)	**<K2-O>**	**2.827(6)**
K2-O1 (×2)	2.840(9)		
K2-O3 (×2)	2.879(9)		
K3-O5 (×6)	2.726(9)	**<K3-O>**	**2.726(9)**
B1-O3	1.308(8)	**<B1-O>**	**1.354(5)**
B1-O4	1.369(7)		
B1-O2	1.385(1)		
B2-O2	1.276(8)	**<B2-O>**	**1.352(4)**
B2-O1	1.303(2)		
B2-O5	1.478(3)		
B3-O3 (×2)	1.461(6)	**<B3-O>**	**1.471(8)**
B3-O5 (×2)	1.481(9)		

Table S2. Refined cell lattice parameters from Le Bail fitting on PXRD data

$K_7Ca(Y_{1-x}Bi_x)_2(B_5O_{10})_3$	***a*** **(Å)**	***c*** **(Å)**	***V*** **(Å^3)**
x = 0.01	13.2565(3)	14.9923(4)	2281.7(1)
0.02	13.2568(4)	14.9929(5)	2290.9(2)
0.03	13.2549(3)	14.9989(5)	2282.1(1)
0.04	13.2596(3)	14.9950(4)	2283.1(1)
0.05	13.2608(4)	14.9925(4)	2283.2(1)
0.06	13.2595(3)	14.9922(3)	2284.3(1)
$K_7Ca(Y_{1-y}Eu_y)_2(B_5O_{10})_3$	***a*** **(Å)**	***c*** **(Å)**	***V*** **(Å^3)**
y = 0.10	13.2538(3)	14.9996(4)	2281.9(1)
0.3	13.2766(6)	15.0061(8)	2290.7(2)
0.5	13.3048(7)	15.0232(2)	2303.1(3)
0.7	13.3248(8)	15.0535(1)	2314.7(7)
0.8	13.3338(7)	15.0521(8)	2315.9(2)
1	13.3382(6)	15.1081(9)	2327.8(3)
$K_7Ca(Y_{0.99-z}Bi_{0.01}Eu_z)_2(B_5O_{10})_3$	***a*** **(Å)**	***c*** **(Å)**	***V*** **(Å^3)**
z = 0	13.2573(4)	14.9938(5)	2282.2(2)
0.05	13.2591(3)	14.9997(5)	2283.7(1)
0.15	13.2697(4)	15.0014(6)	2287.6(2)
0.2	13.2746(5)	15.0181(6)	2291.9(2)
0.3	13.2908(5)	15.0123(6)	2296.6(2)
0.5	13.3103(1)	15.0238(3)	2305.1(4)

0.7	13.3251(5)	15.0767(7)	2318.4(9)
0.9	13.3381(2)	15.0949(4)	2325.7(5)

Table S3. Quantum yields for $K_7Ca(Y_{1-x}Bi_x)_2(B_5O_{10})_3$ under the excitation of 281 nm

x	**Quantum yield (%)**
0.01	95.0
0.02	86.6
0.03	59.1
0.04	50.0
0.05	46.0
0.06	13.2

Table S4. CIE chromaticity coordinates for $K_7Ca(Y_{1-y}Eu_y)_2(B_5O_{10})_3$ under 229 or 392 nm excitation

y	λ_{ex} **= 229 nm**	λ_{ex} **= 392 nm**
0.1	(0.640, 0.360)	(0.637, 0.363)
0.3	(0.641, 0.359)	(0.640, 0.360)
0.5	(0.641, 0.359)	(0.640, 0.359)
0.7	(0.641, 0.359)	(0.641, 0.359)
0.8	(0.637, 0.362)	(0.641, 0.359)
1	(0.642, 0.358)	(0.642, 0.358)

Table S5. Quantum yields for $K_7Ca(Y_{1-y}Eu_y)_2(B_5O_{10})_3$ under the excitation of 392 nm

y	**Quantum yield (%)**
0.10	68.90
0.30	95.00
0.50	87.59
0.70	82.35
0.80	80.73
1	76.43

Table S6. CIE chromaticity coordinates for $K_7Ca(Y_{0.99-z}Bi_{0.01}Eu_z)_2(B_5O_{10})_3$ under 281 nm excitation

z	**CIE chromaticity coordinate**
0	(0.168, 0.008)
0.05	(0.438, 0.204)
0.15	(0.542, 0.287)
0.2	(0.583, 0.318)
0.3	(0.605, 0.335)
0.5	(0.619, 0.348)
0.7	(0.623, 0.347)
0.9	(0.623, 0.349)

Table S7. Quantum yields for $K_7Ca(Y_{0.99-z}Bi_{0.01}Eu_z)_2(B_5O_{10})_3$ under the excitation of 281 nm

z	**Quantum yield (%)**

0.05	95.14
0.15	99.79
0.20	98.02
0.30	98.24
0.50	98.71
0.70	91.71
0.90	80.80

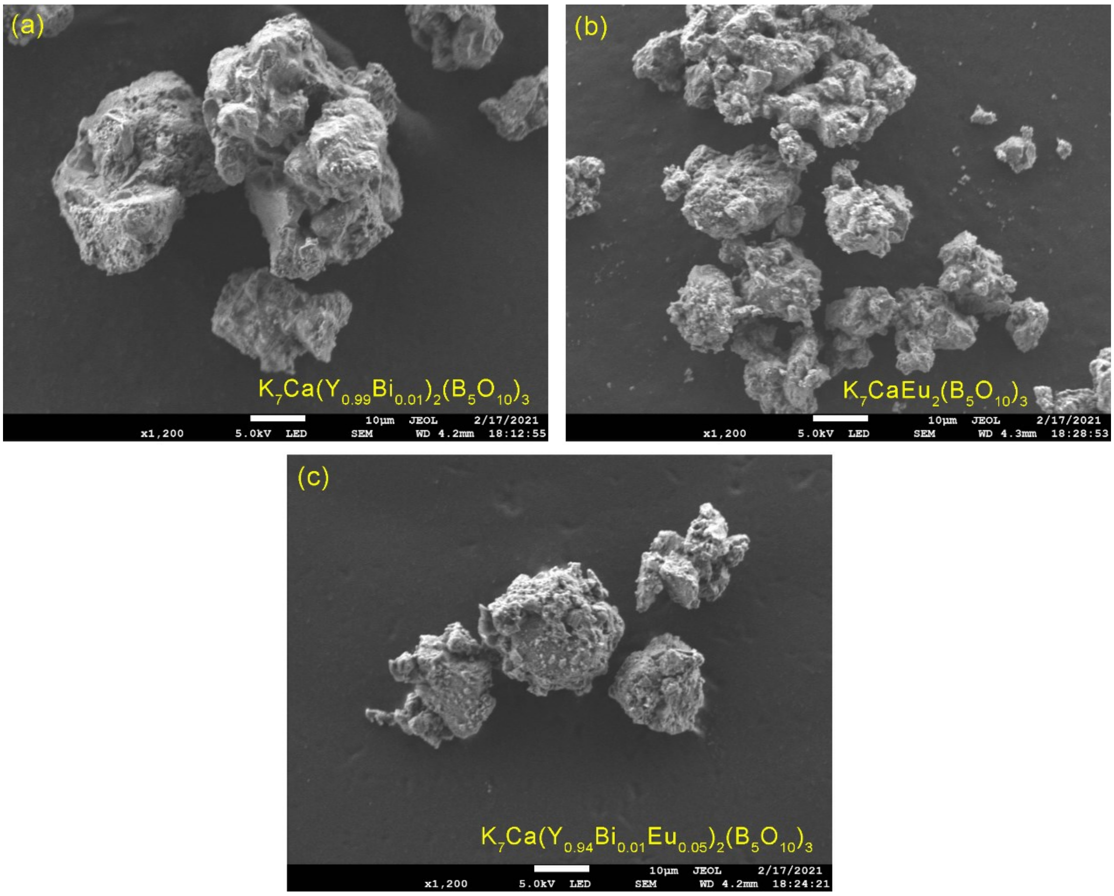
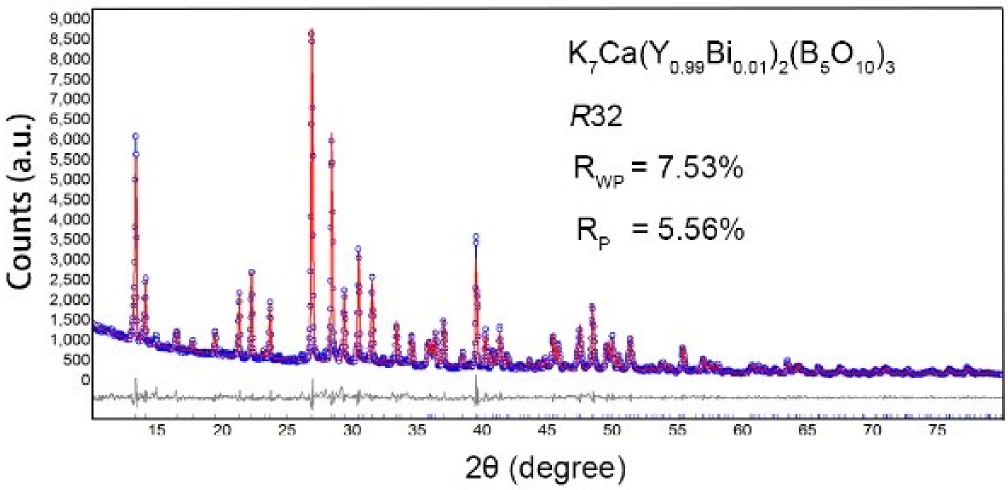
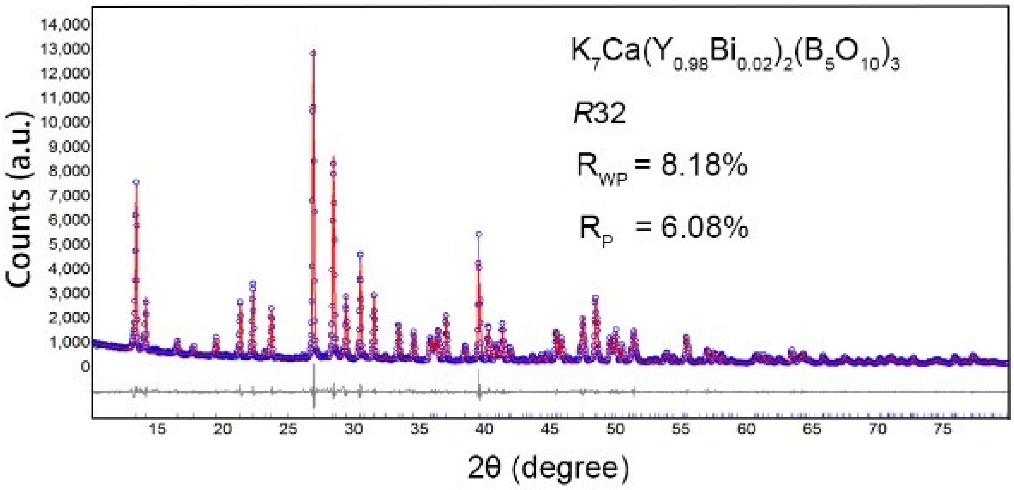
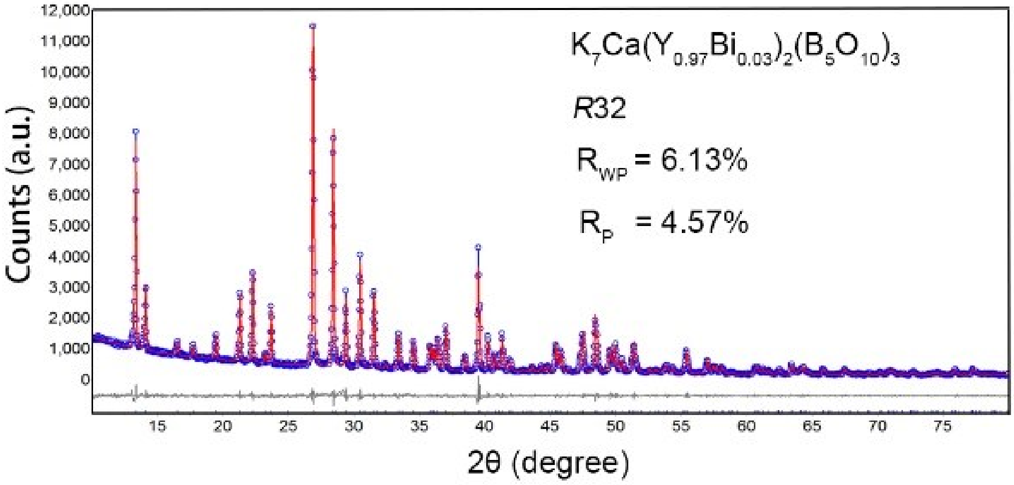
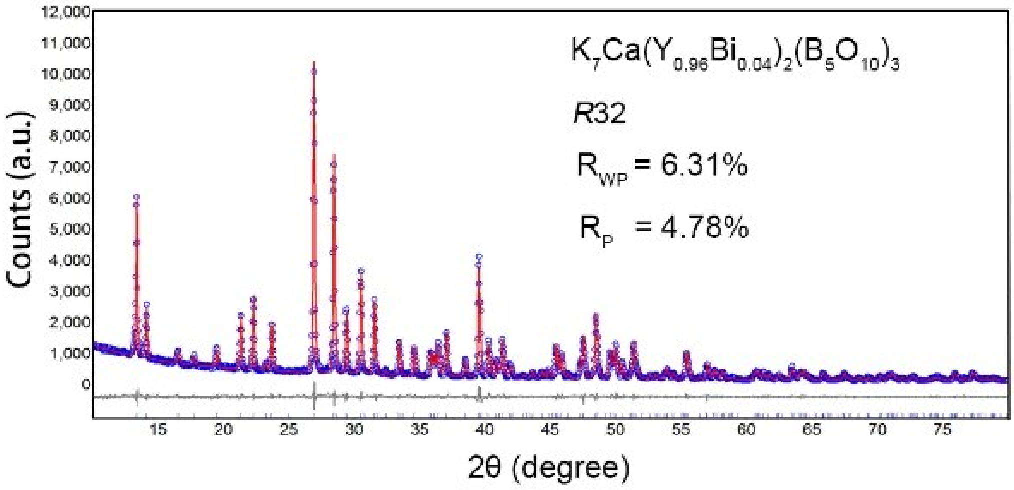


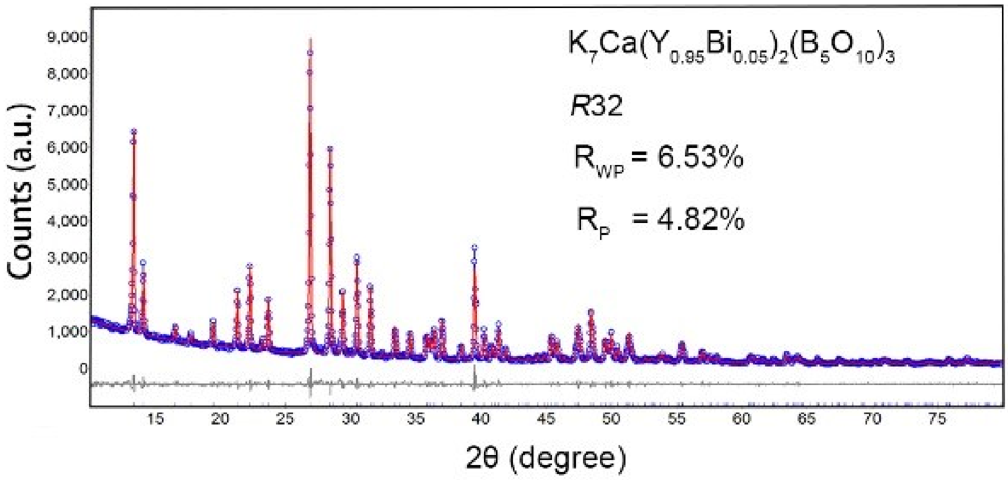
Fig. S1. SEM images for representative samples (a) $K_7Ca(Y_{0.99}Bi_{0.01})_2(B_5O_{10})_3$, (b) $K_7CaEu_2(B_5O_{10})_3$, and (c) $K_7Ca(Y_{0.94}Bi_{0.01}Eu_{0.05})_2(B_5O_{10})_3$.

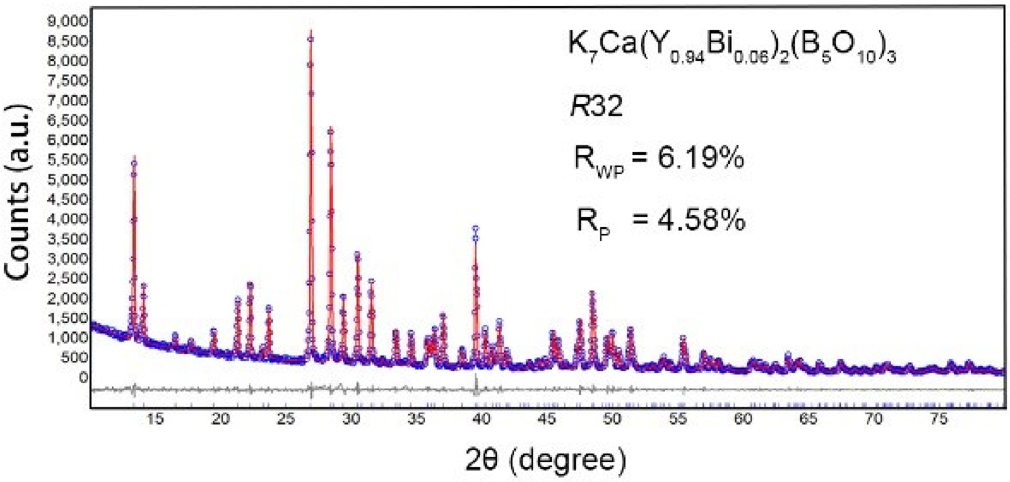


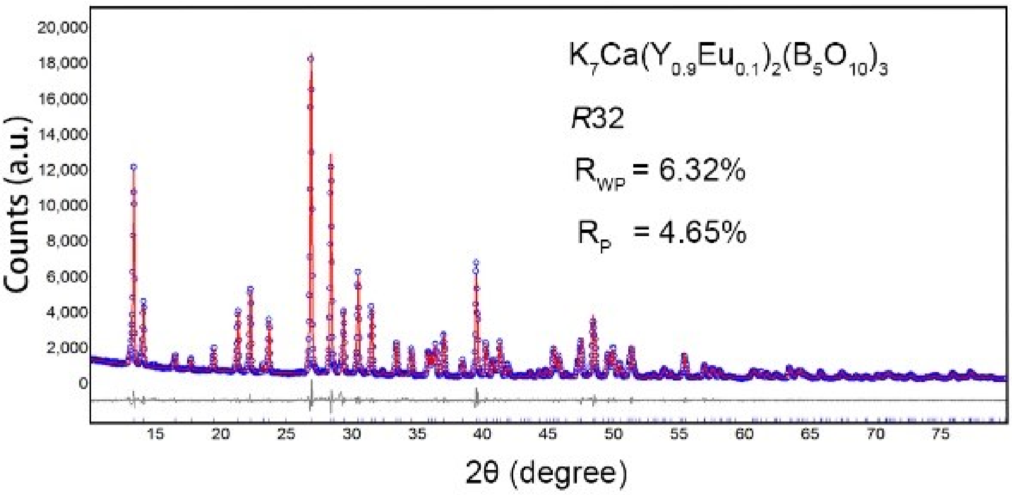

$K_7Ca(Y_{0.98}Bi_{0.02})_2(B_5O_{10})_3$
$R32$
R_{WP} = 8.18%
R_P = 6.08%
Counts (a.u.)
2θ (degree)

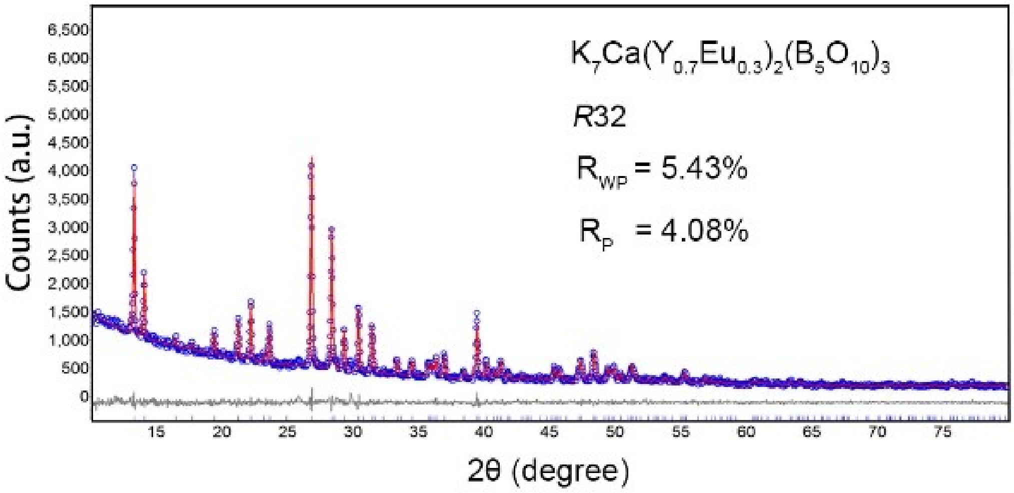

$K_7Ca(Y_{0.97}Bi_{0.03})_2(B_5O_{10})_3$
$R32$
R_{WP} = 6.13%
R_P = 4.57%
Counts (a.u.)
2θ (degree)

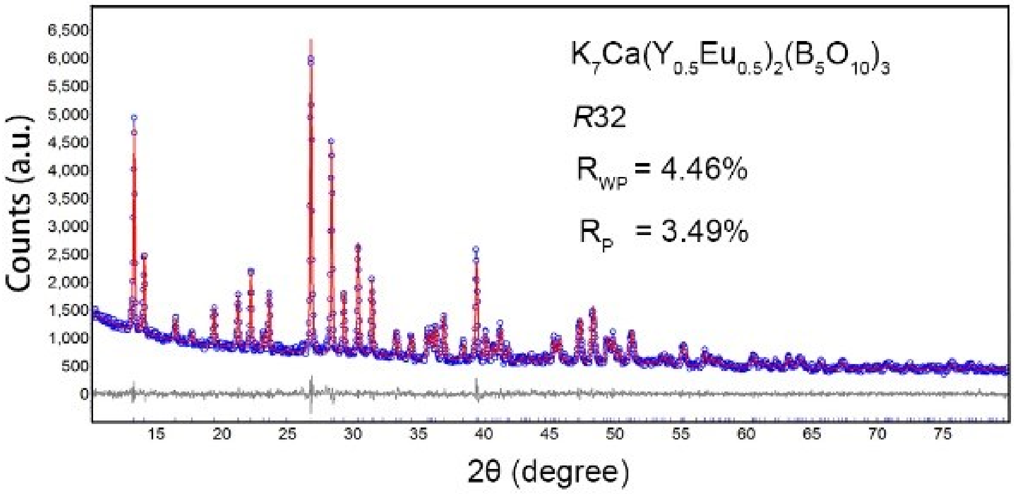

$K_7Ca(Y_{0.96}Bi_{0.04})_2(B_5O_{10})_3$
$R32$
R_{WP} = 6.31%
R_P = 4.78%
Counts (a.u.)
2θ (degree)

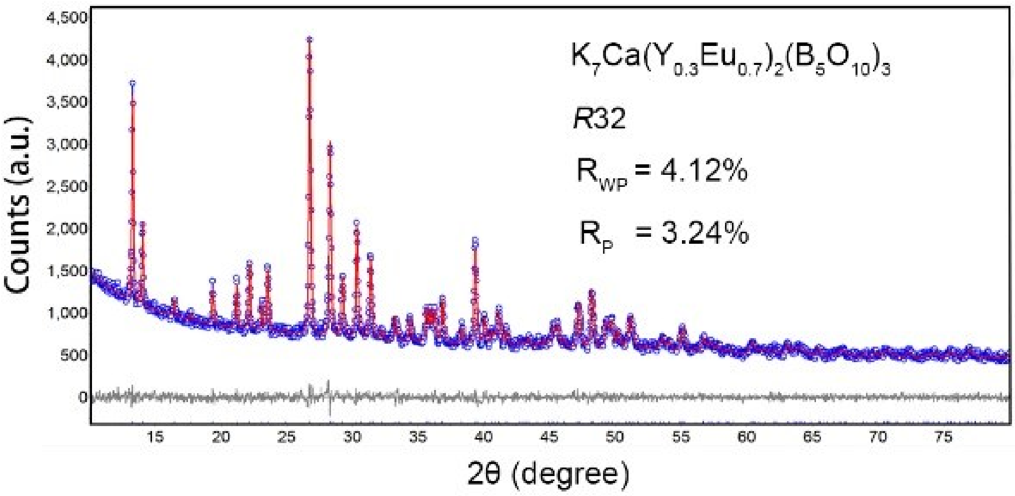

$K_7Ca(Y_{0.95}Bi_{0.05})_2(B_5O_{10})_3$
*R*32
R_{WP} = 6.53%
R_P = 4.82%
Counts (a.u.)
2θ (degree)

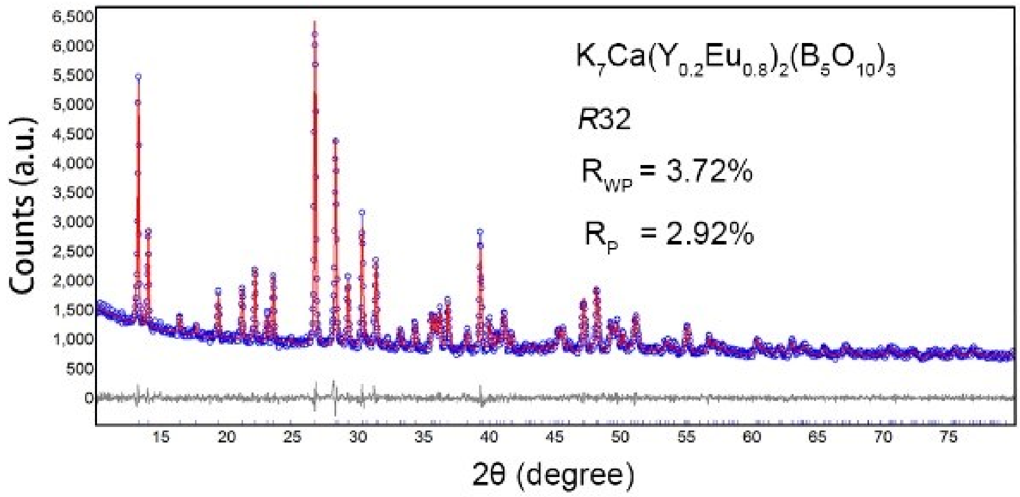

$K_7Ca(Y_{0.94}Bi_{0.06})_2(B_5O_{10})_3$
*R*32
R_{WP} = 6.19%
R_P = 4.58%
Counts (a.u.)
2θ (degree)

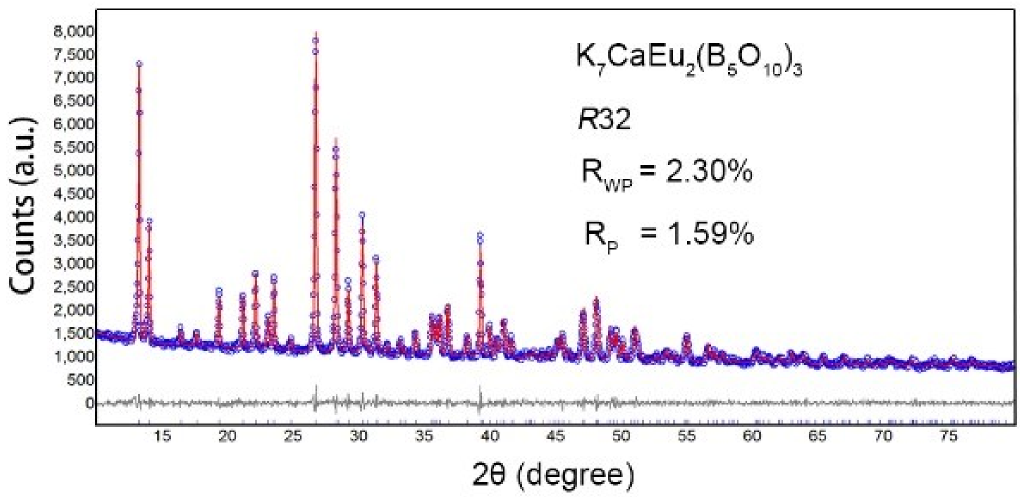

$K_7Ca(Y_{0.9}Eu_{0.1})_2(B_5O_{10})_3$
*R*32
R_{WP} = 6.32%
R_P = 4.65%
Counts (a.u.)
2θ (degree)

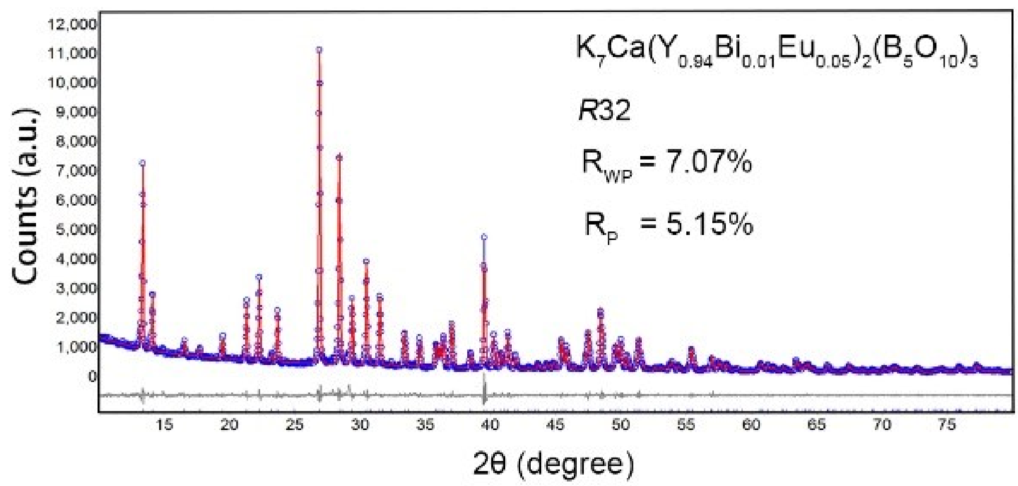

$K_7Ca(Y_{0.7}Eu_{0.3})_2(B_5O_{10})_3$
*R*32
R_{WP} = 5.43%
R_P = 4.08%
Counts (a.u.)
2θ (degree)

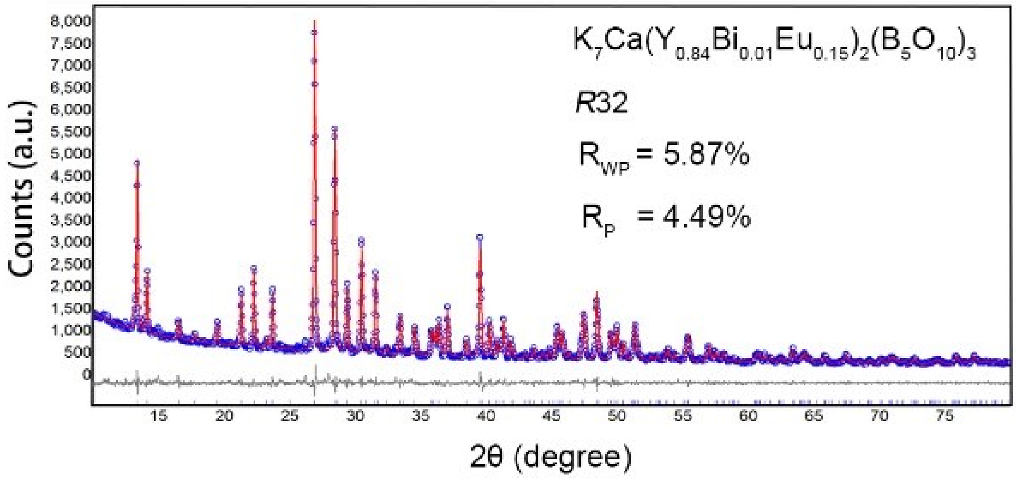

$K_7Ca(Y_{0.5}Eu_{0.5})_2(B_5O_{10})_3$
*R*32
R_{WP} = 4.46%
R_P = 3.49%
Counts (a.u.)
2θ (degree)

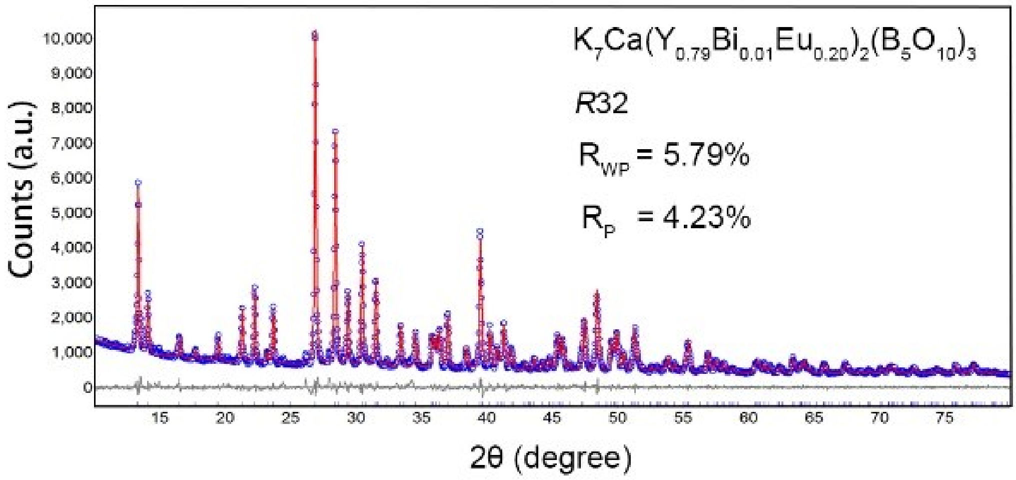

$K_7Ca(Y_{0.3}Eu_{0.7})_2(B_5O_{10})_3$
*R*32
R_{WP} = 4.12%
R_P = 3.24%
Counts (a.u.)
2θ (degree)

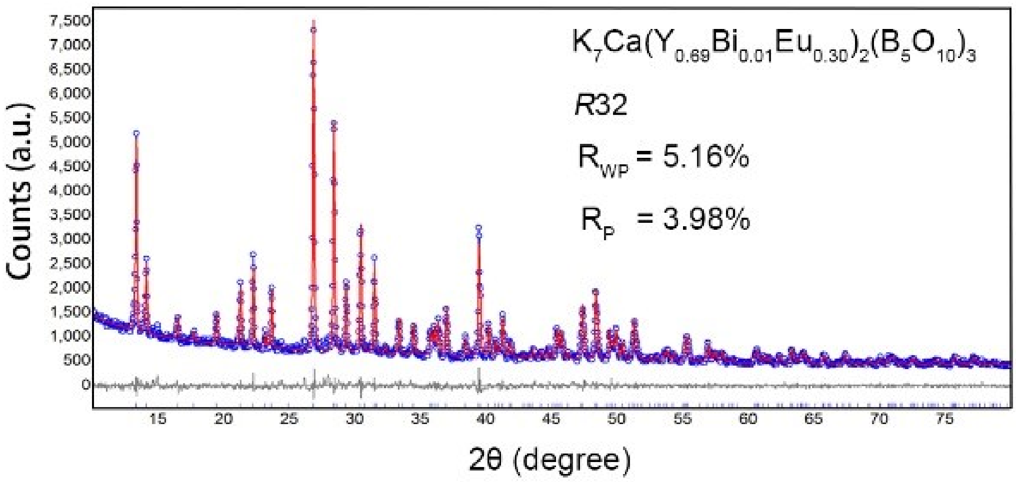

$K_7Ca(Y_{0.2}Eu_{0.8})_2(B_5O_{10})_3$
*R*32
R_{WP} = 3.72%
R_P = 2.92%
Counts (a.u.)
2θ (degree)


$K_7CaEu_2(B_5O_{10})_3$
*R*32
R_{WP} = 2.30%
R_P = 1.59%
Counts (a.u.)
2θ (degree)


$K_7Ca(Y_{0.94}Bi_{0.01}Eu_{0.05})_2(B_5O_{10})_3$
*R*32
R_{WP} = 7.07%
R_P = 5.15%
Counts (a.u.)
2θ (degree)


$K_7Ca(Y_{0.84}Bi_{0.01}Eu_{0.15})_2(B_5O_{10})_3$
*R*32
R_{WP} = 5.87%
R_P = 4.49%
Counts (a.u.)
2θ (degree)


$K_7Ca(Y_{0.79}Bi_{0.01}Eu_{0.20})_2(B_5O_{10})_3$
*R*32
R_{WP} = 5.79%
R_P = 4.23%
Counts (a.u.)
2θ (degree)


$K_7Ca(Y_{0.69}Bi_{0.01}Eu_{0.30})_2(B_5O_{10})_3$
*R*32
R_{WP} = 5.16%
R_P = 3.98%
Counts (a.u.)
2θ (degree)

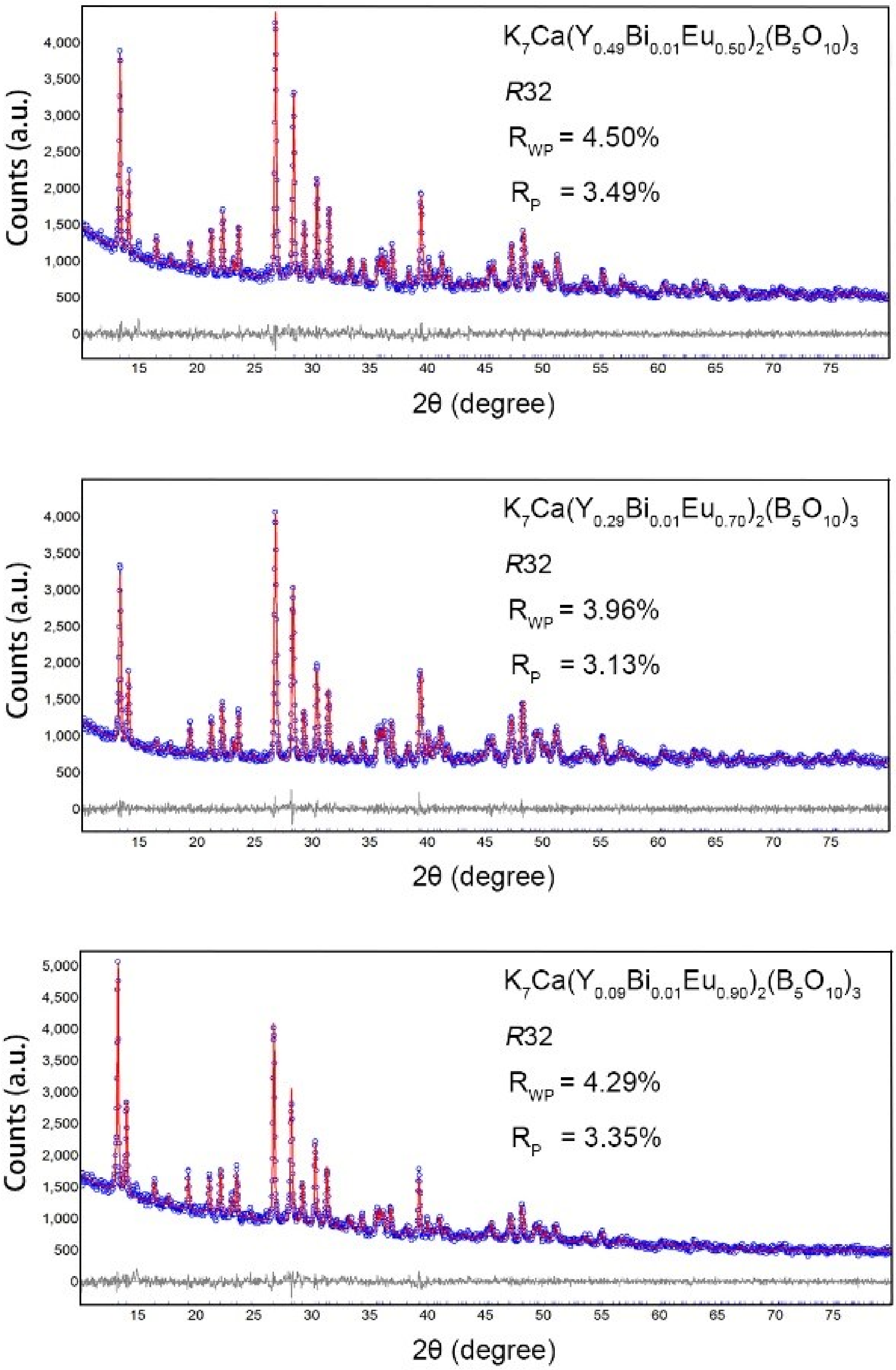


Fig. S2. Final convergences of Le Bail fitting for $K_7Ca(Y_{1-x}Bi_x)_2(B_5O_{10})_3$ ($0.01 \leq x \leq 0.06$), $K_7Ca(Y_{1-y}Eu_y)_2(B_5O_{10})_3$ ($0.10 \leq y \leq 1$) and $K_7Ca(Y_{0.99-z}Bi_{0.01}Eu_z)_2(B_5O_{10})_3$ ($0.05 \leq z \leq 0.90$). Blue circles, red and gray lines represent the observed, simulated data and the difference between them, respectively.

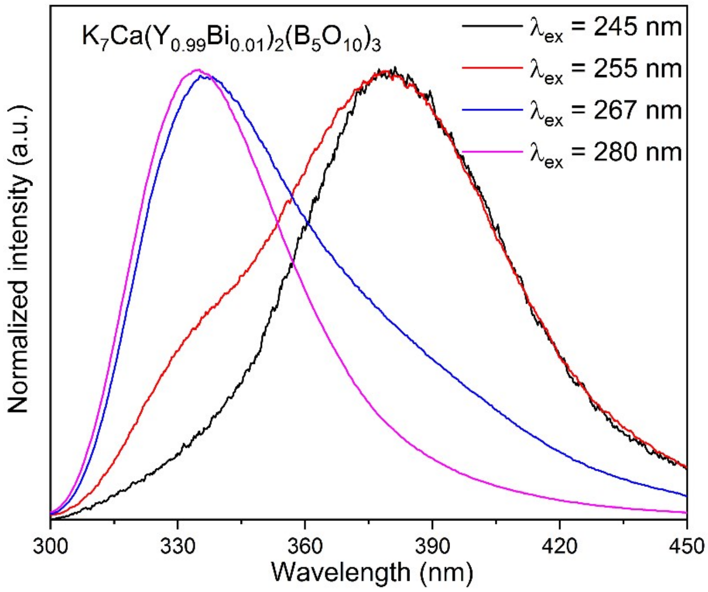


Fig. S3. Normalized emission spectra for $K_7Ca(Y_{0.99}Bi_{0.01})_2(B_5O_{10})_3$ under different excitation wavelengths.

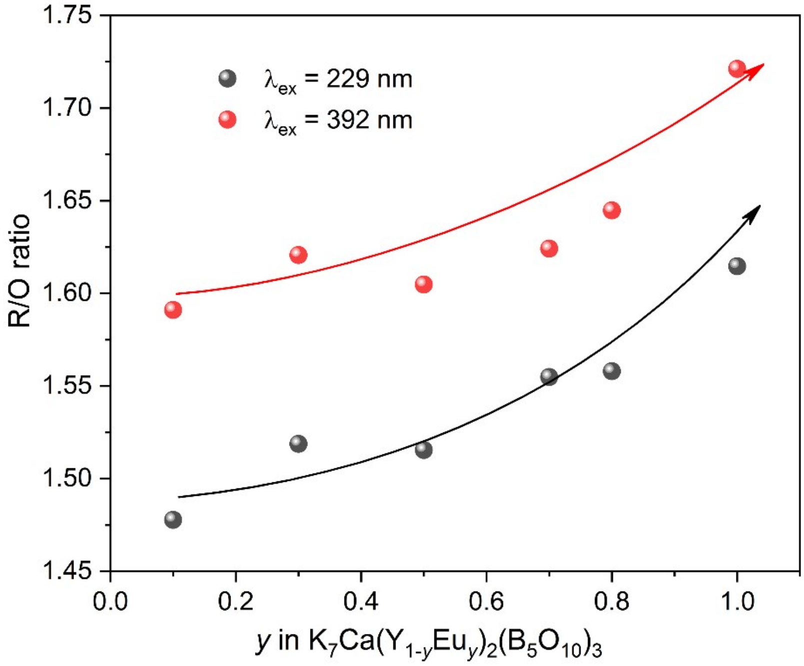


Fig. S4. Estimated R/O ratios for $K_7Ca(Y_{1-y}Eu_y)_2(B_5O_{10})_3$ ($0.10 \leq y \leq 1$) under CT or the strongest *f*-*f* excitations.

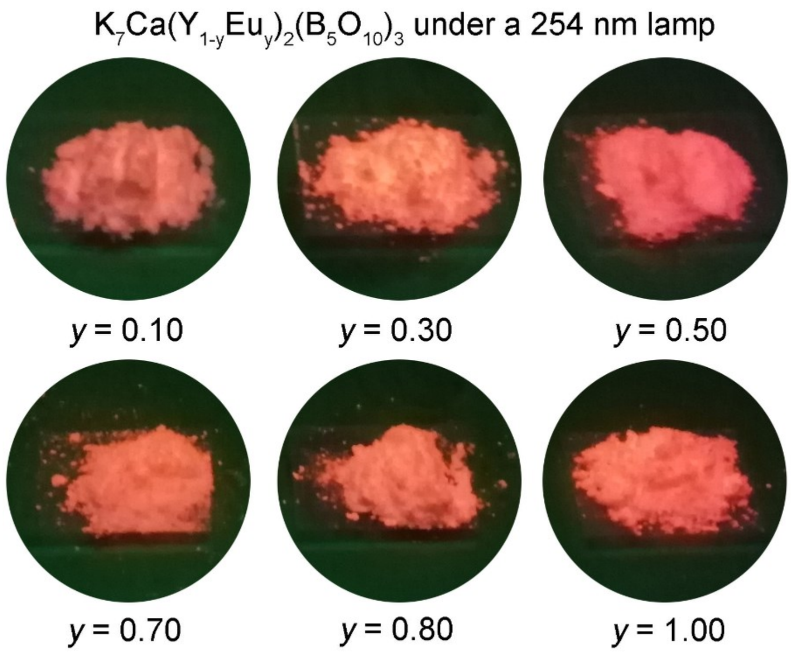


Fig. S5. Photographs for $K_7Ca(Y_{1\text{-}y}Eu_y)_2(B_5O_{10})_3$ ($0.10 \leq y \leq 1$) under a 254 nm UV lamp.

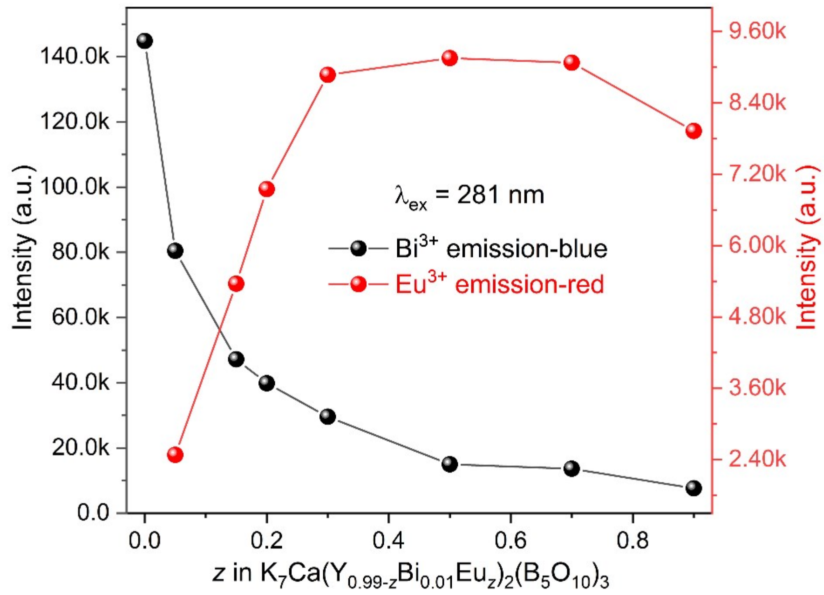


Fig. S6. Corresponding intensity for Bi^{3+} (blue) and Eu^{3+} (red) emissions for $K_7Ca(Y_{0.99\text{-}z}Bi_{0.01}Eu_z)_2(B_5O_{10})_3$ ($0 \leq z \leq 0.9$) under the excitation of 281 nm.

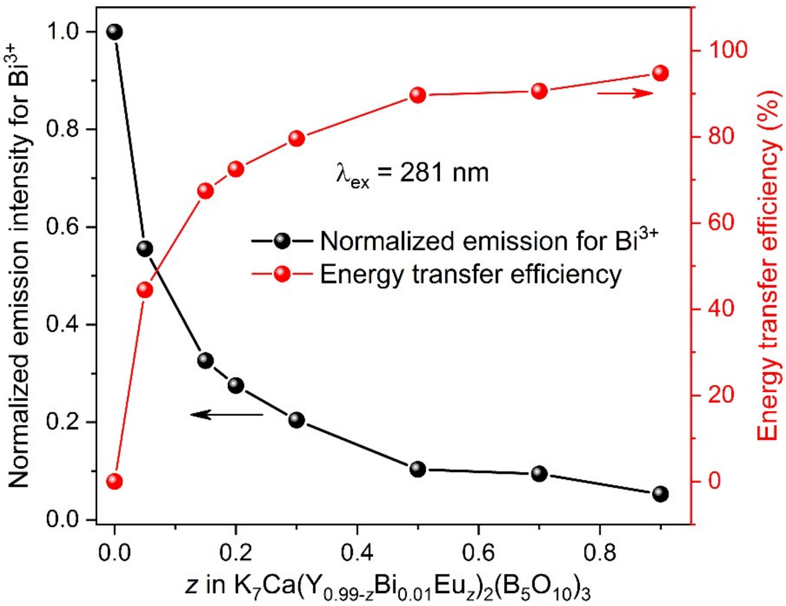


Fig. S7. Normalized Bi^{3+} emission intensity and the so-calculated energy transfer efficiency for $K_7Ca(Y_{0.99-z}Bi_{0.01}Eu_z)_2(B_5O_{10})_3$ ($0 \leq z \leq 0.9$) under 281 nm excitation.