

Supporting Information

Structure and Luminescence Characteristics of Self-activated Vanadate Garnet

Phosphors

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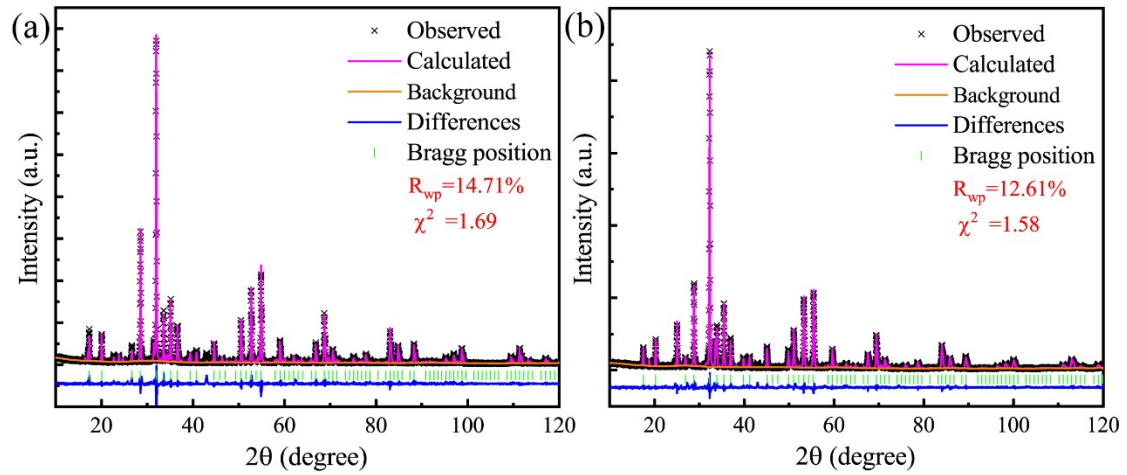


Fig. S1 (a) Rietveld refinement patterns of $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$ samples. (b) Rietveld refinement patterns of $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ samples.

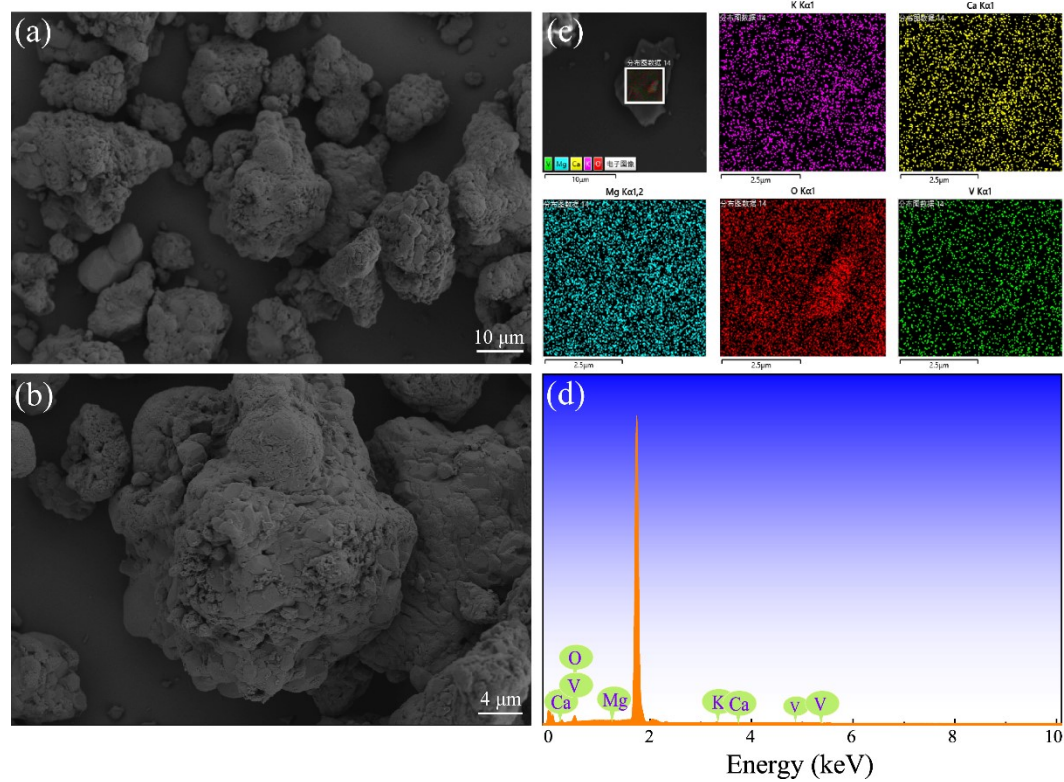


Fig. S2 (a-b) SEM images of $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$ sample at different magnifications, (c) and (d) elemental mapping and EDS spectrum of the sample.

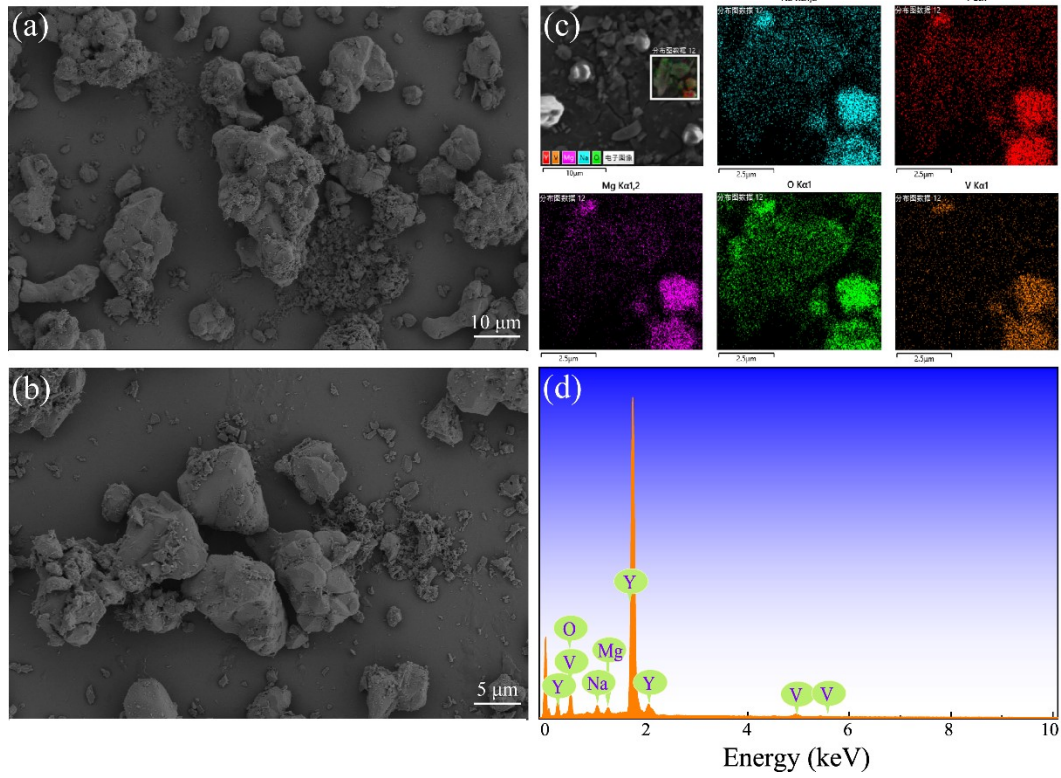


Fig. S3 (a-b) SEM images of $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ sample at different magnifications, (c) and (d) elemental mapping and EDS spectrum of the sample.

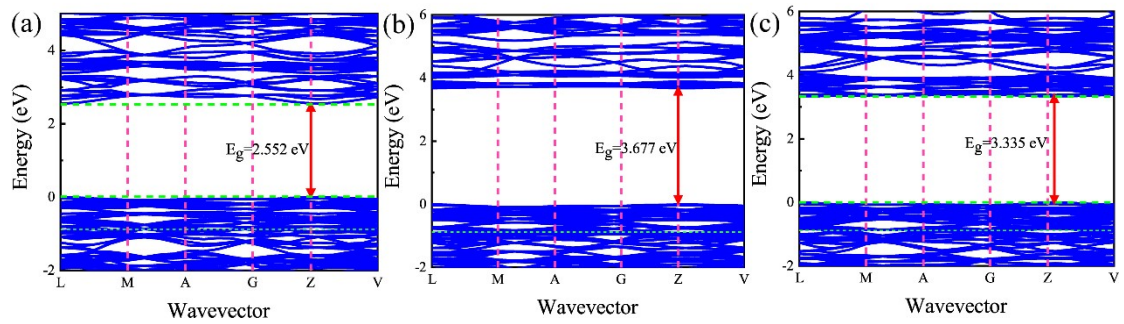


Fig. S4 Calculation of the energy band structure of $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ samples.

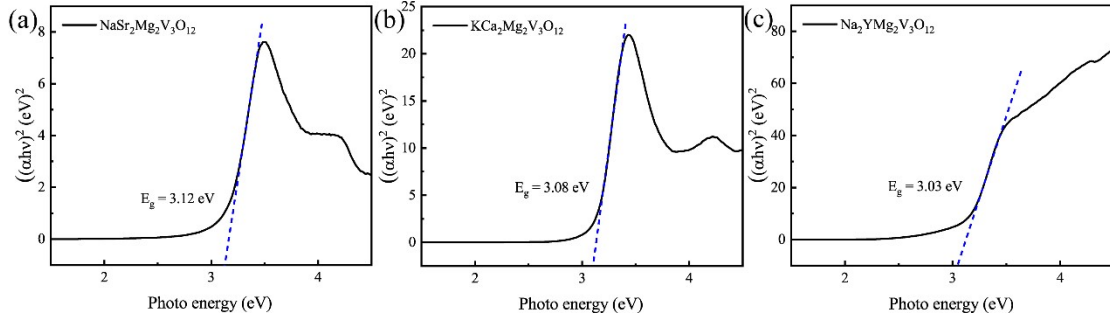


Fig. S5 Tauc plot of the $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ matrix fitted from the absorption spectrum.

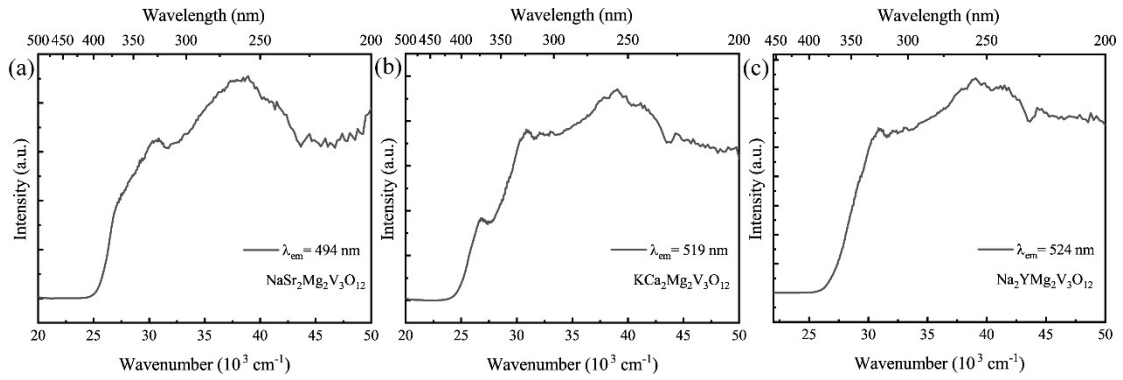


Fig. S6 PLE spectrum of $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ samples.

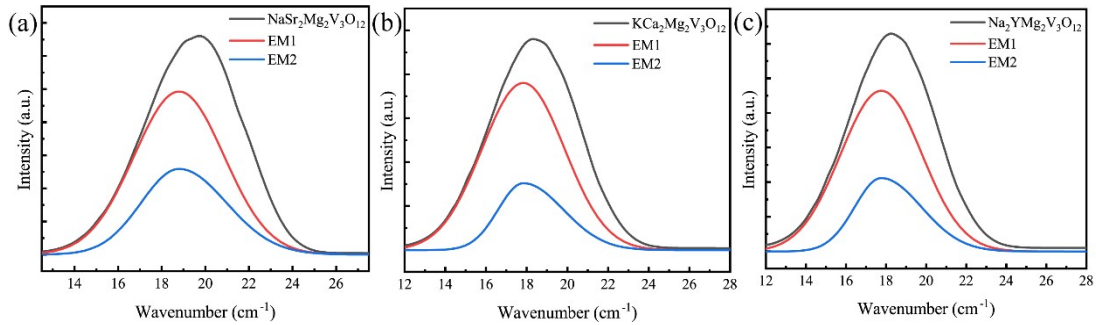


Fig. S7 Gauss deconvolutions of the PL spectra of the $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ phosphors excited at 266 nm

Table. S1 The lifetime of the $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ phosphor with 355 nm and 266 nm excitation.

Phosphor	Lifetime (μs)	
	355 nm	266 nm
$\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$	7.67	6.15
$\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$	5.81	5.72
$\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$	2.48	2.06

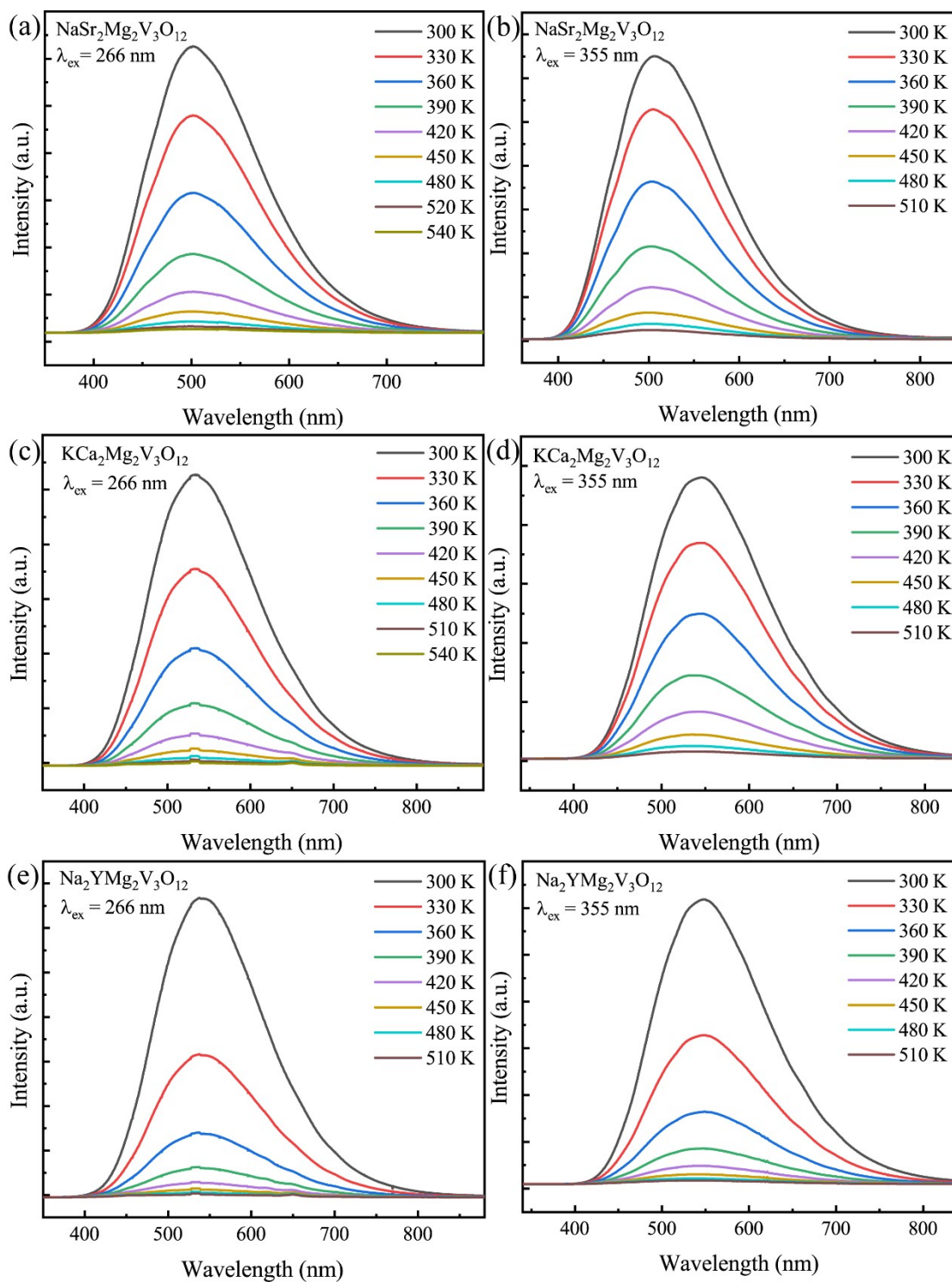


Fig. S8 (a-b) Temperature-dependence of the PL intensity of the $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$ phosphors. (c-d) Temperature-dependence of the PL intensity of the $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$ phosphors. (e-f) Temperature-dependence of the PL intensity of the $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ phosphors.

Table S2 The normalized luminescence integral intensities of the samples at different temperatures.

Temperatur	$\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$	$\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$	$\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$
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e	266 nm	355 nm	266 nm	355 nm	266 nm	355 nm
300 K	1	1	1	1	1	1
330 K	0.76860	0.80439	0.68256	0.77639	0.48598	0.53496
360 K	0.50239	0.55139	0.40818	0.52230	0.22371	0.26556
390 K	0.28761	0.32742	0.21842	0.30619	0.10612	0.13302
420 K	0.15207	0.18628	0.11058	0.17390	0.05425	0.06989
450 K	0.08057	0.09794	0.05679	0.08938	0.03084	0.03917
480 K	0.04354	0.05676	0.03055	0.04831	0.01886	0.02335
510 K	0.02490	0.03405	0.01777	0.02765	0.01886	0.01566

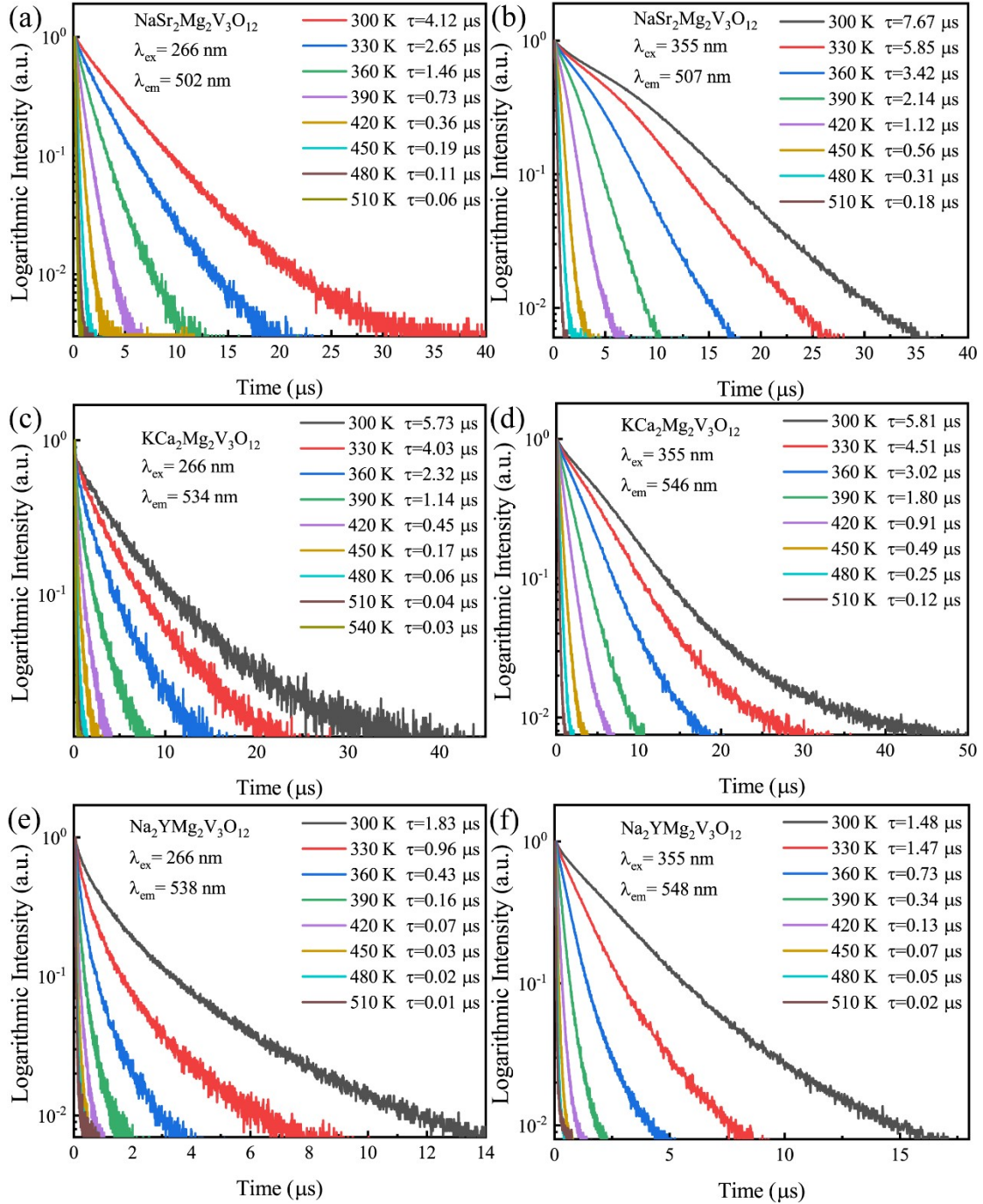


Fig. S9 The decay curves of red emission in $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ phosphors at different temperatures (300-510 K)

Table. S3 The lifetime of the $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ phosphor at different temperatures.

Temperature e	Lifetime (μs)					
	$\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$		$\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$		$\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$	
	266 nm	355 nm	266 nm	355 nm	266 nm	355 nm
300 K	4.120	7.666	5.725	5.815	1.834	2.481
330 K	2.648	5.854	4.027	4.508	0.956	1.467
360 K	1.464	3.420	2.317	3.024	0.428	0.732
390 K	0.726	2.135	1.141	1.799	0.161	0.341
420 K	0.364	1.124	0.455	0.914	0.069	0.131
450 K	0.188	0.564	0.166	0.486	0.026	0.072
480 K	0.106	0.312	0.062	0.246	0.017	0.053
510 K	0.059	0.184	0.037	0.120	0.012	0.023

Table S4 Absorption Rates, Internal QE, and External QE of the $\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, $\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$, and $\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$ Phosphors excited at 324 nm.

Phosphors	Absorption rate (%)	QE	
		Internal (%)	External (%)
$\text{NaSr}_2\text{Mg}_2\text{V}_3\text{O}_{12}$	72.2	84.5	61.0
$\text{KCa}_2\text{Mg}_2\text{V}_3\text{O}_{12}$	72.1	85.5	61.6
$\text{Na}_2\text{YMg}_2\text{V}_3\text{O}_{12}$	74.7	16.4	12.3

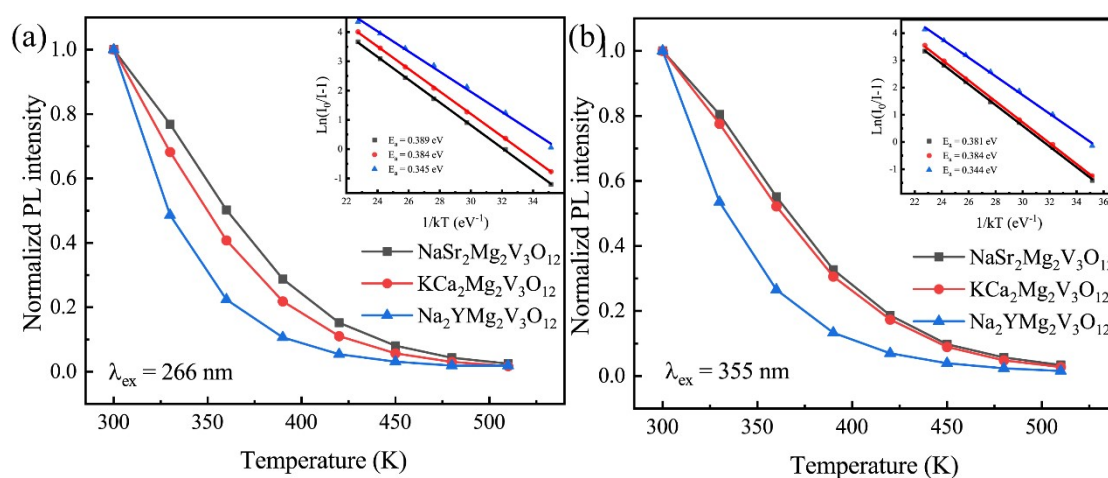


Fig. S10 Temperature-dependence of the PL intensity of the NSM, KCM, and NYM phosphors under excitation at (a) 355 nm and (b) 266 nm. Insert shows the calculated activation energy for thermal quenching.

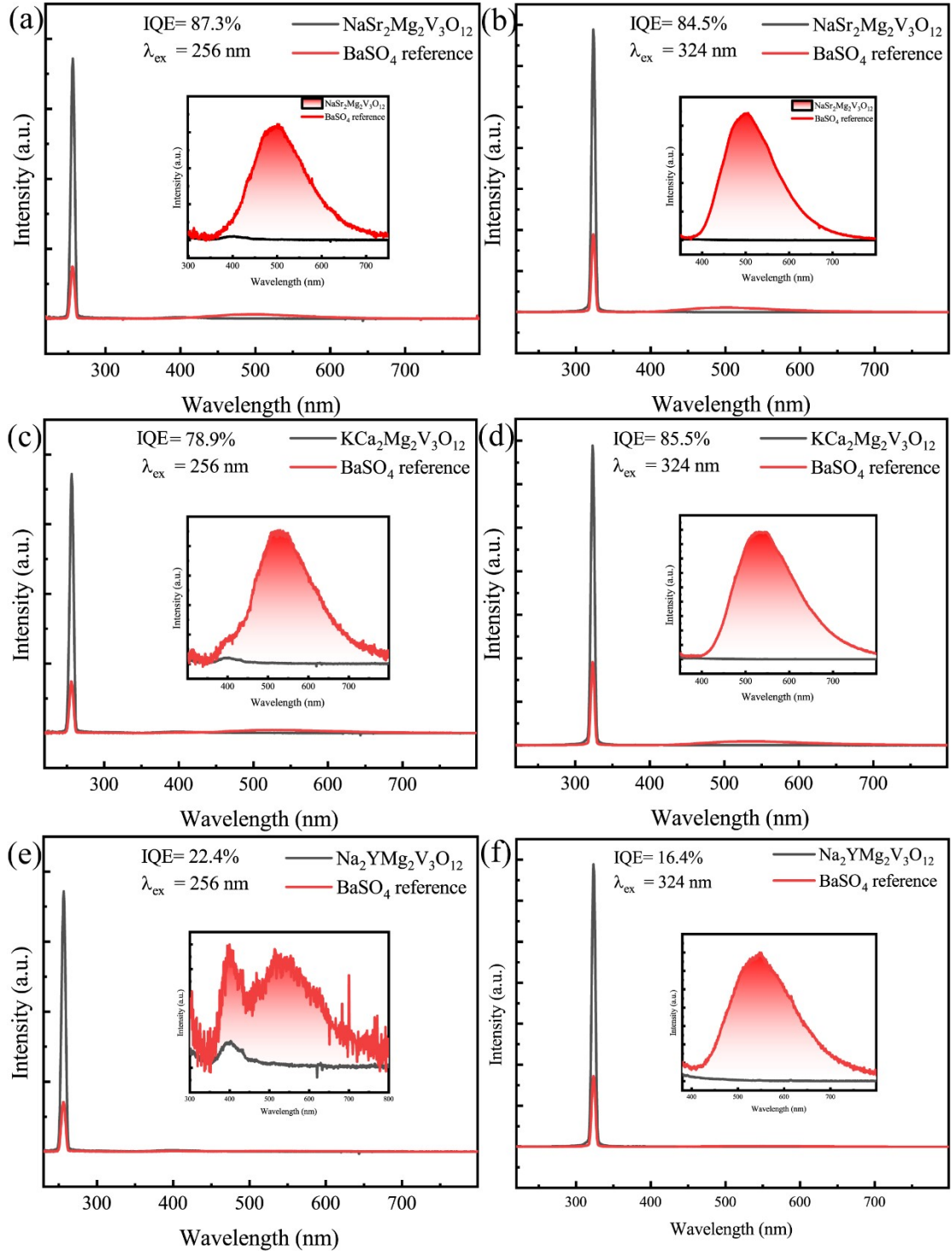


Fig. S11 (a,b) The IQE map of the NaSr₂Mg₂V₃O₁₂ sample. (c,d) The IQE map of the KCa₂Mg₂V₃O₁₂ sample. (e,f) The IQE map of the Na₂YMg₂V₃O₁₂ sample.