SUPPORTING INFORMATION

In situ preparation of highly luminescent Sb^{3+}/Mn^{2+} co-doped Cs_2KInCl_6 lead-free double perovskite in PVDF matrix and application to white light emitting diode and anti-counterfeiting

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Table S1. The positions, PL intensities, FWHM and CIE coordinates of the dual peaks in different regions of the Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1.

Position	Peak1 wavelength (nm)	Peak1 PL intensity	Peak2 Wavelength (nm)	Peak2 PL intensity	FWHM	CIE
1	501	906059.1	633	702325.1	230.6416	(0.3357, 0.3833)
2	500	943006.4	634	724365.4	232.7982	(0.3333, 0.3800)
3	501	953537.7	634	775487.4	231.0202	(0.3396, 0.3822)
4	501	1008074.3	634	835016.5	229.9310	(0.3415, 0.3832)
5	501	1028279.9	634	862647.2	232.2089	(0.3424, 0.3825)
6	501	1054715.6	633	839332.0	230.0910	(0.3380, 0.3830)
7	500	1066223.9	634	887090.8	232.7456	(0.3399, 0.3779)
8	500	1070569.8	634	852467.1	231.8963	(0.3360, 0.3793)
9	500	1071127.5	633	875282.5	231.1717	(0.3388, 0.3801)
10	500	1075901.7	633	886219.9	234.4710	(0.3398, 0.3801)
11	501	1096263.9	633	881045.3	230.9752	(0.3388, 0.3830)
12	501	1096271.3	632	932813.7	232.2579	(0.3441, 0.3833)
13	501	1104425.1	632	898658.9	232.8296	(0.3390, 0.3806)
14	502	1137986.1	634	952250.0	232.7614	(0.3438, 0.3849)
15	501	1142087.1	632	903584.3	230.7596	(0.3379, 0.3834)
16	501	1181506.1	634	981440.0	232.5075	(0.3395, 0.3791)

Table S2. Weight percentage and atomic percentage of partial relevant elements in Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1.

Element	**Weight %**	**Atomic %**
F (K)	85.93	94.92
Cs (L)	4.00	0.63
K (K)	0.83	0.45
In (L)	2.17	0.40
Cl (K)	5.08	3.01
Sb (L)	0.80	0.14
Mn (K)	1.18	0.45

Table S3. Bi-exponential fitting results of decay curves for Sb^{3+}/Mn^{2+} co-doped Cs_2KInCl_6/PVDF composite films

Mn to Sb ratio	A_1 (%)	τ_1 (ms)	A_2 (%)	τ_2 (ms)	τ_{ave} (ms)
8:1	0.248	2.558	0.721	15.813	15.114
12:1	0.265	1.062	0.651	14.522	14.134
16:1	0.294	3.689	0.621	16.155	14.941
20:1	0.388	1.310	0.533	14.759	13.944

Table S4. Comparison of optical properties of the other perovskite/polymer composite films by in situ stratety.

Composite film	Color	PLQY (%)	Ref
$MAPbBr_3$/PVDF	green	94.6	1
$CsPbBr_3$/PVDF	green	65	2
Mn^{2+} doped $MAPbCl_3$/PVDF	red	22.8	3
$MAPbBr_3$/pHEA	green	11	4
$MAPbBr_3$/PAN	green	71	5
$MAPbBr_3$/PVA	green	95.3	6
Cd^{2+} doped $FAPbBr_3$/PVDF	green	74.4	7
$Cs_3Cu_2I_5$/PMMA	blue	64	8
$Cs_2Na_{0.8}Ag_{0.2}BiCl_6$/PMMA	orange	21.52	9
Sb^{3+}/Mn^{2+} co-doped Cs_2KInCl_6/PVDF	**white**	**86.98**	**This work**

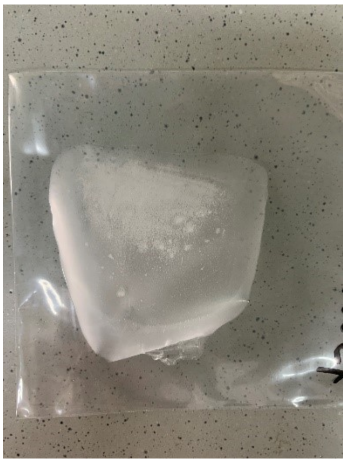

Fig. S1 The photograph of Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1 obtained by direct heating at 100°C under sunlight.

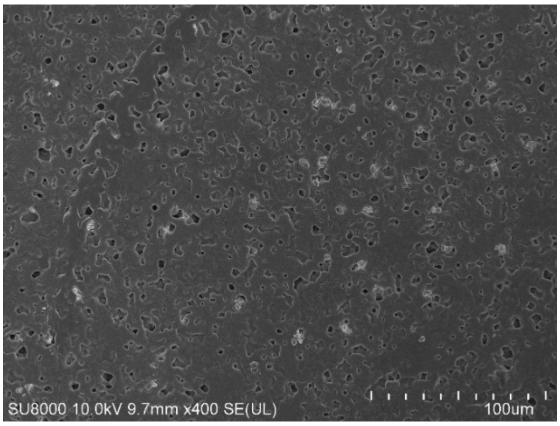

Fig. S2 SEM image of Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1 obtained by direct heating at 100°C.

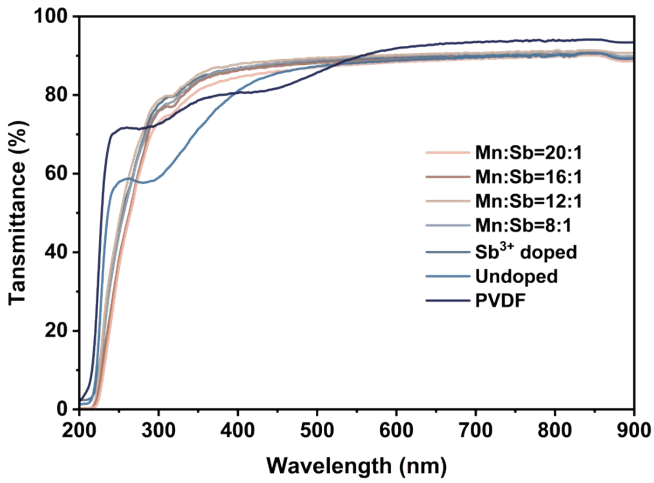

Fig. S3 Transmission spectrum of pure PVDF film and composite films.

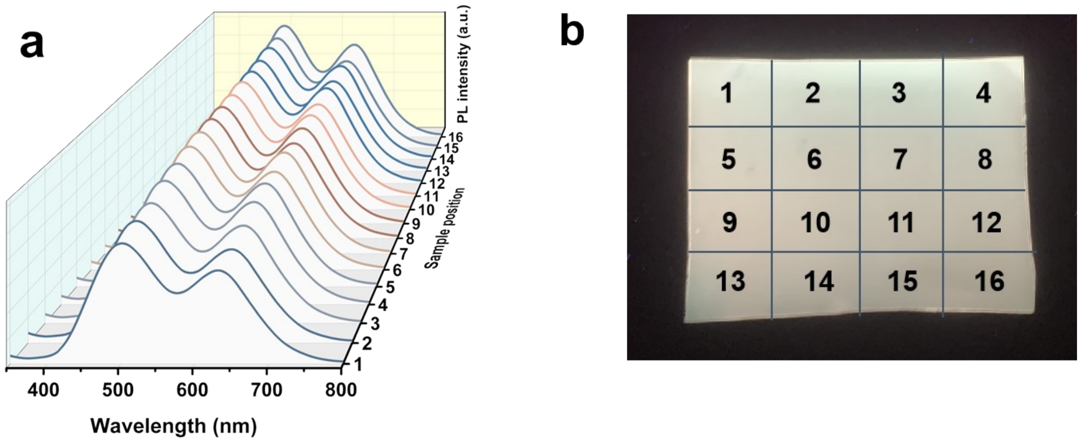

Fig. S4 PL spectra of different regions of the Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1.

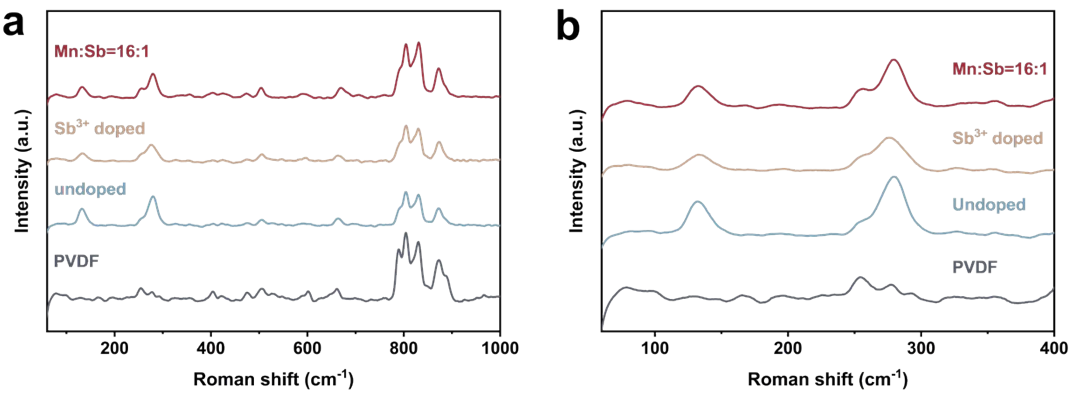

Fig. S5 (a) Raman spectrum of pure PVDF film, undoped, Sb^{3+} doped and co-doped Cs_2KInCl_6/PVDF composite films. (b) Raman spectrum of pure PVDF film, undoped, Sb^{3+} doped and co-doped Cs_2KInCl_6/PVDF composite films at 50 and 400 cm^{-1}.

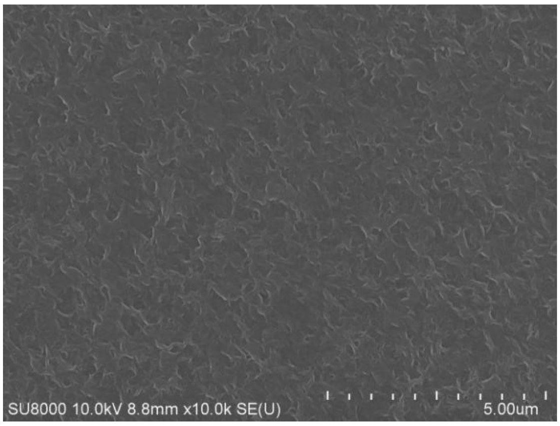

Fig. S6 SEM image of pure PVDF film.

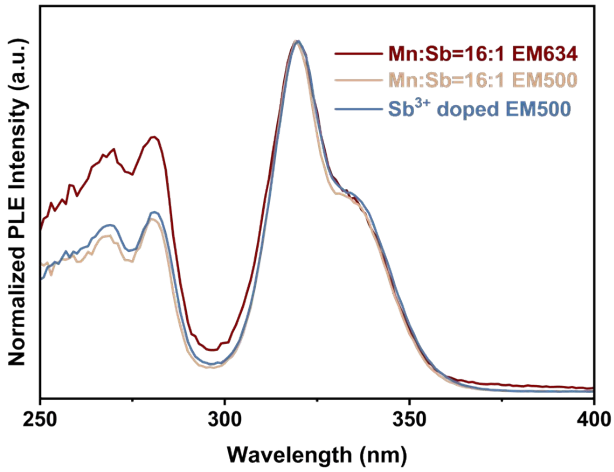

Fig. S7 PLE spectra of Cs_2KInCl_6/PVDF composite films with single Sb^{3+} doped and co-doped.

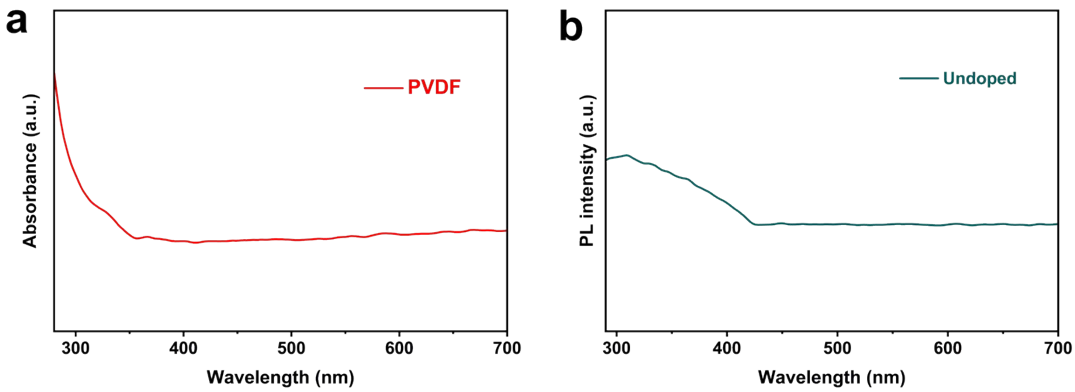

Fig. S8 (a) and (b). Absorption spectrum of pure PVDF film and Cs_2KInCl_6/PVDF composite film.

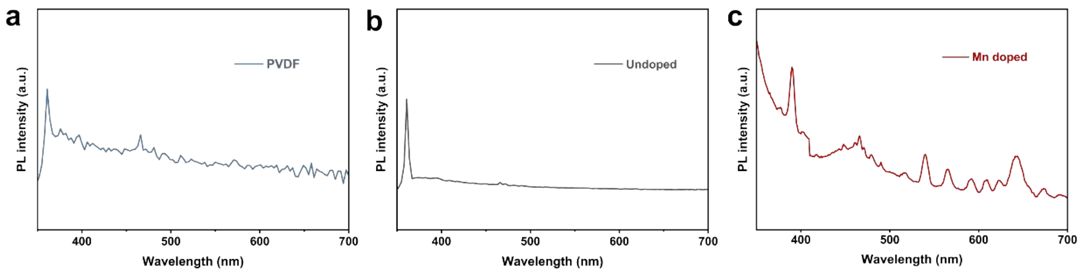

Fig. S9 (a), (b) and (c). PL spectrum of pure PVDF film, Cs_2KInCl_6/PVDF composite film and Mn^{2+} doped Cs_2KInCl_6/PVDF composite film.

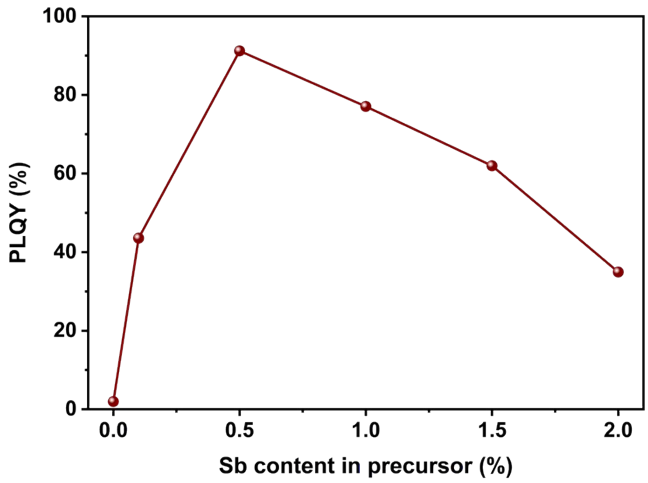

Fig. S10 PLQY of Cs_2KInCl_6/PVDF composite films with different Sb content in precursor.

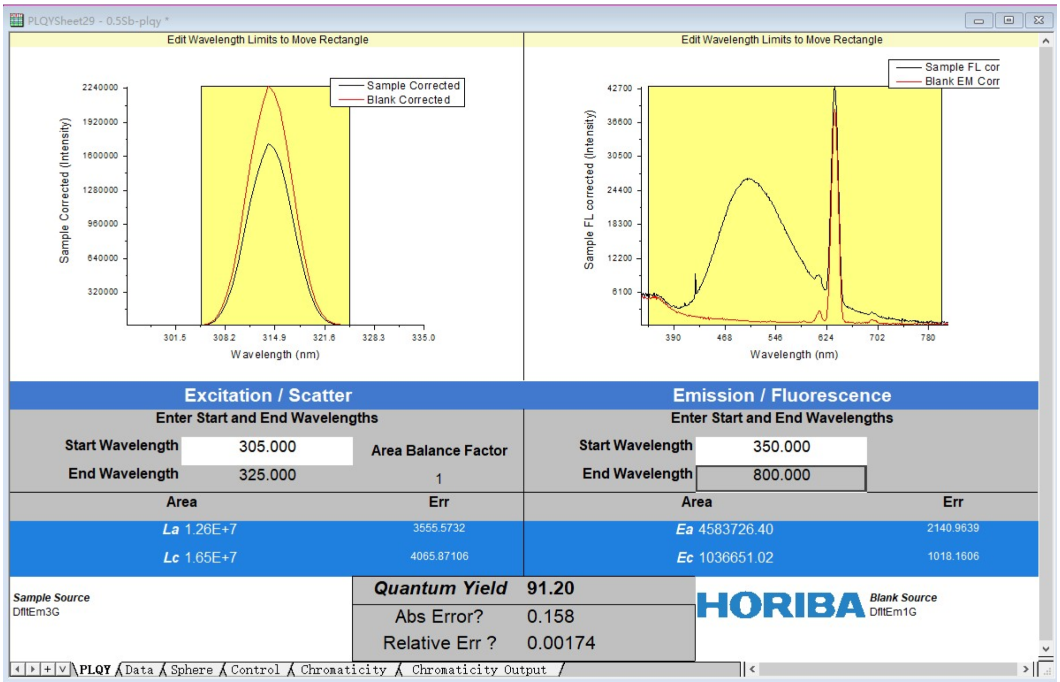

Fig. S11 PLQY of 0.5%Sb: Cs_2KInCl_6/PVDF composite film.

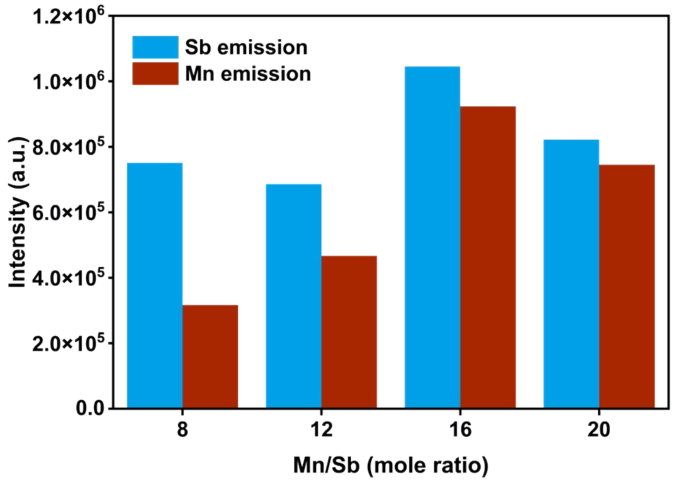

Fig. S12 PL intensity of Cs_2KInCl_6/PVDF composite films with different Mn/Sb feeding ratio.

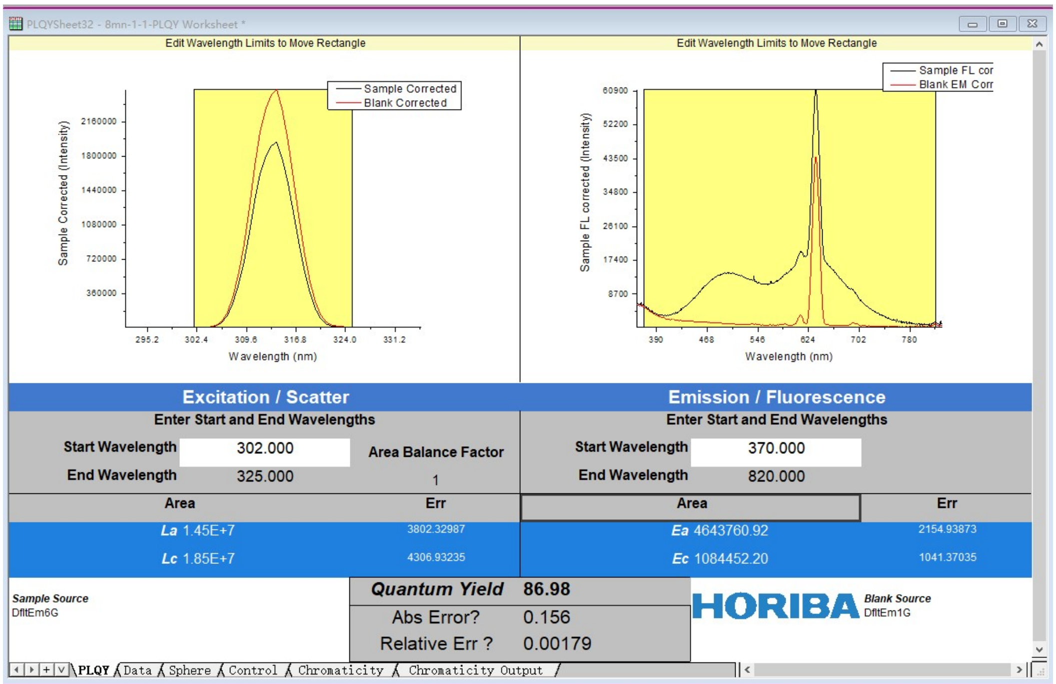

Fig. S13 PLQY of Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1.

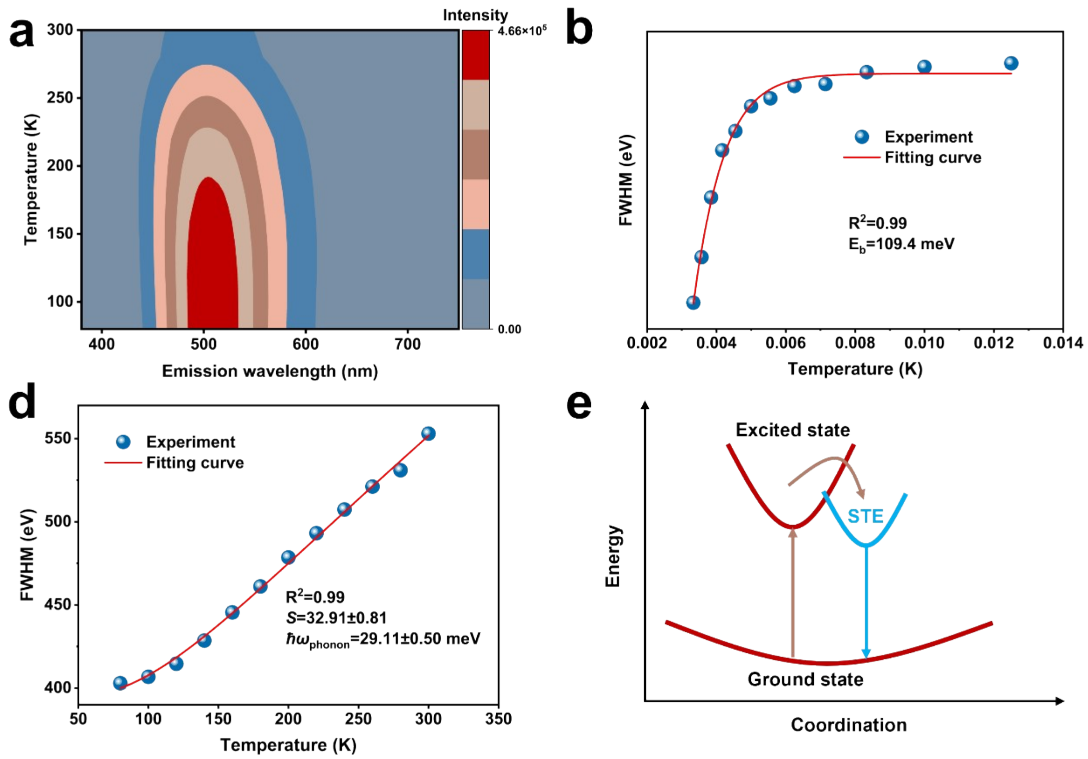

Fig. S14 (a) Pseudo-color maps of temperature-dependent PL spectra of the Sb^{3+} doped Cs2KInCl6/PVDF composite film (λ_{ex}=320nm). And its corresponding (b) PL intensity versus 1/T and fitting results. (c) Fwhm versus temperature and the fitting results. (d) Schematic diagram of photophysical processes.

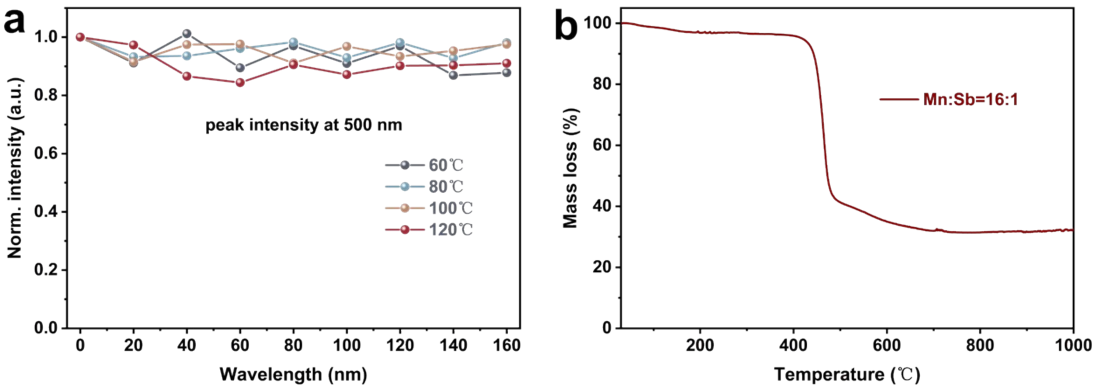

Fig. S15 (a) Stability of Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1 under heating. (b) Thermogravimetric analysis thermogram of Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1.

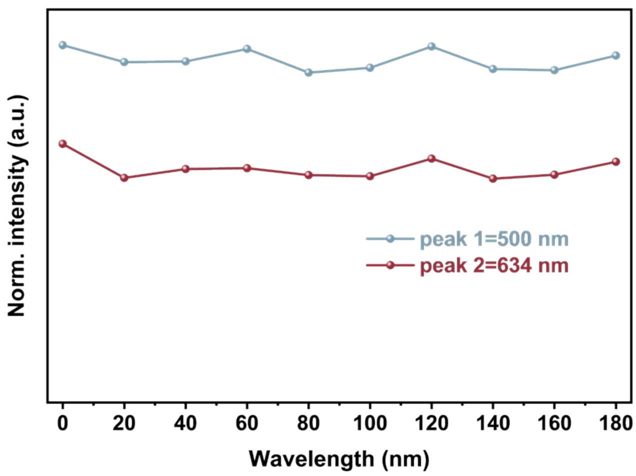

Fig. S16 Stability of Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1 under illumination.

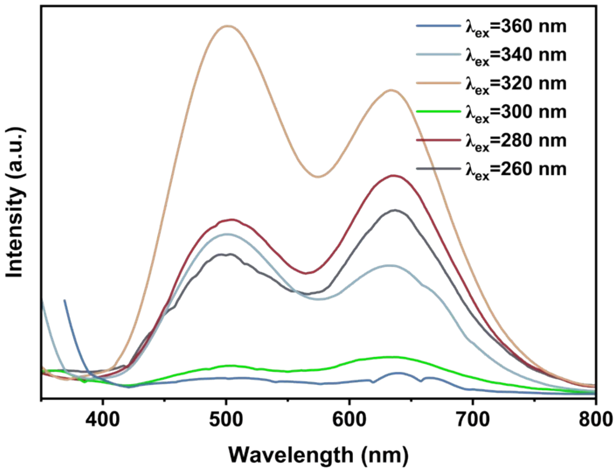

Fig. S17 Variable excitation spectrum of Cs_2KInCl_6/PVDF composite film with Mn to Sb ratio of 16:1

References

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