Electronic Supplementary Material

Excitation Wavelength Tunable White Light Emission in Vacancy-Ordered Double Perovskite

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Experimental Section

Materials and Chemicals:

Hydrochloric acid with a mass fraction of 37% was purchased from Tianjin Fuchen Chemical Corp. Some chemicals, such as cesium chloride (CsCl, Macklin, 99.99%), hafnium chloride ($HfCl_4$, Macklin, 99%) and antimony chloride ($SbCl_3$, Aladdin, 99%) were purchased from Kaimate Chemical Corp (Tianjin, China).

Synthesis of CHC:xSb^{3+} vacancy-ordered double perovskite:

CHC:xSb^{3+} vacancy-ordered double perovskites were synthesized by precipitation method. The whole experiment process is completed at room temperature. Variable ratio of $SbCl_3$ to $HfCl_4$ while keep the whole amount of $SbCl_3$ and $HfCl_4$ to be 1 mmol were dissolved in 8 mL of a 37% HCl solution in a 30 mL beaker, seal and stir for 10 minutes. 2 mmol CsCl dissolved in 5 mL of a 37% HCl solution. And then, slowly add solution of CsCl into beaker with vigorous stirring conditions under. After the reaction is completed, centrifuge and wash with absolute ethanol for precipitation. Finally, put it in an oven at 60°C for 10 hours to get the product.

Measurement and characterization:

X-ray photoelectron spectroscopy (XPS) were recorded by AXIS Supra. ICP-OES analysis were obtained by using a 19 ICP (ICP Multi-Element Standard-19 Elements). Structural analysis is carried outusing a Bruker D8 Advance X-ray diffraction (XRD) machine equipped with Cu K_α rotating anode. Field emission scanning electron microscopy (SEM) images were obtained through JEOL JSM-6510A, the precipitate was redispersed in 1 mL absolute ethanol. Room temperature photoluminescence spectra were recorded by using a F4600 fluorescence spectrophotometer, the excitation light source is provided by a 150 W xenon lamp. The PLQY and PL lifetime were recorded with Edinburgh FLS1000 Instruments spectrofluorometer, a continuous 900W xenon lamp as excitation source. The chromaticity parameter of the WLED were measured by using a HAAS-2000 high accuracy Array Spectrometer (Everfine).

Fabrication of WLEDs devices

WLED consists of a UV chip (λ_{ex} = 320 nm) and CHC:1.69%Sb powder. The

curing glue and phosphor powder are mixed and uniformly coated on the UV chip, and dried at 50 ℃ for 8 hours to obtain WLED.

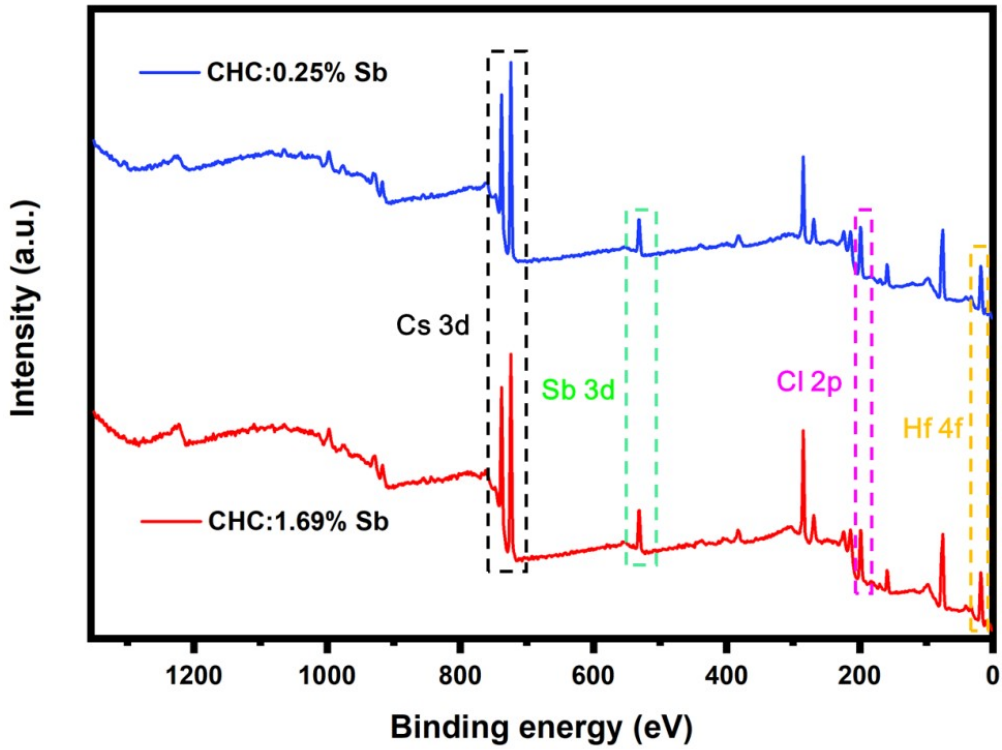

Figure S1. XPS survey spectrum for CHC:0.25%Sb and CHC:1.69%Sb.

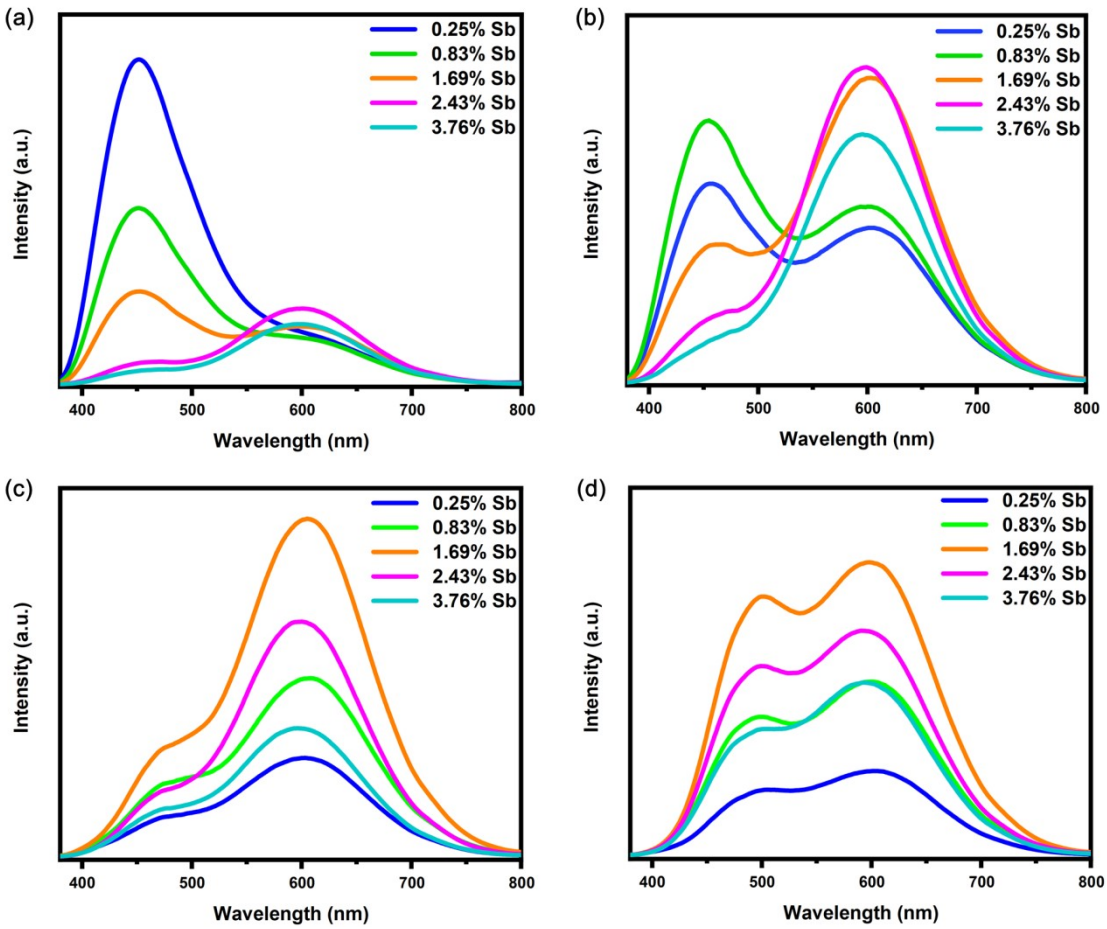

Figure S2. Emission spectra of CHC:xSb, excited by (a) 249 nm, (b) 256 nm, (c) 281 nm and (d) 326 nm.

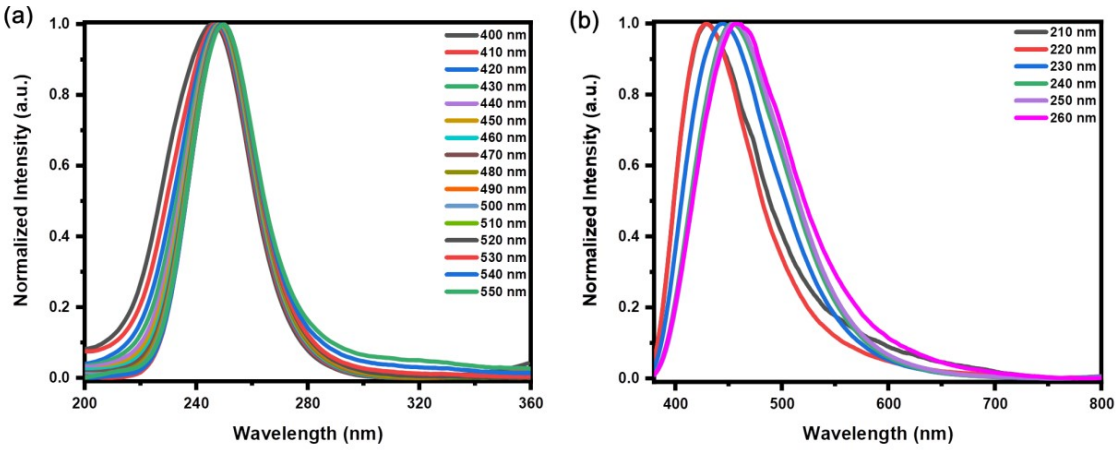

Figure S3. Wavelength-dependent (a) PLE and (b) PL spectra for pure CHC.

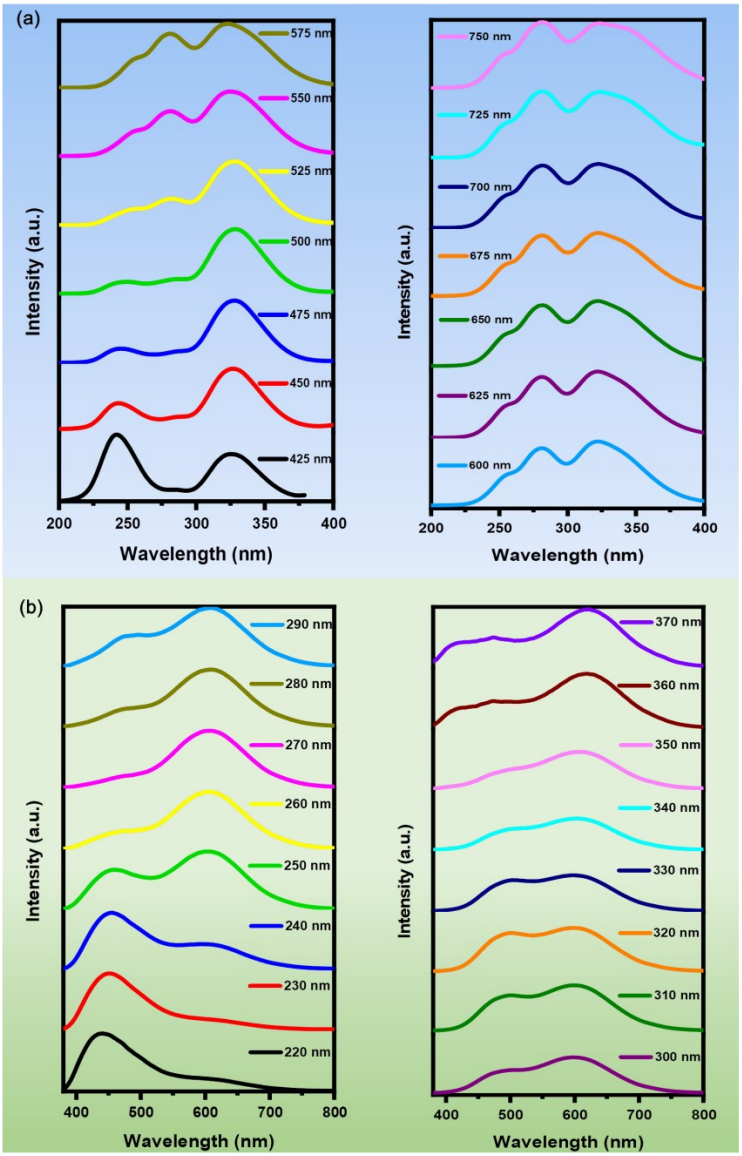

Figure S4. PLE a) and PL b) spectra of recorded from CHC:1.69%Sb with various monitoring and excitation wavelengths.

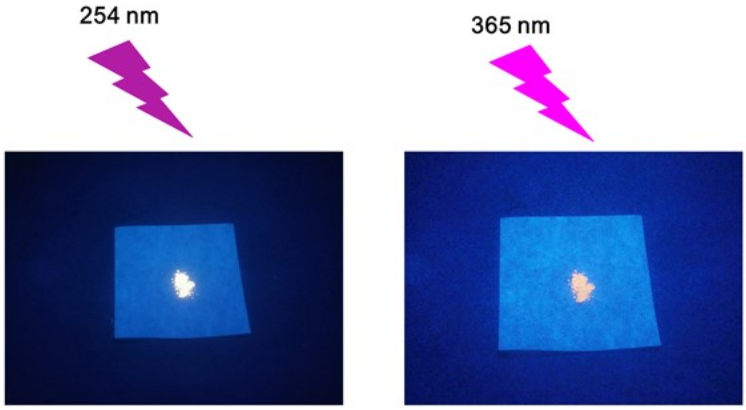

Figure S5. Images of CHC:1.69%Sb under 254 nm and 365 nm lamps.

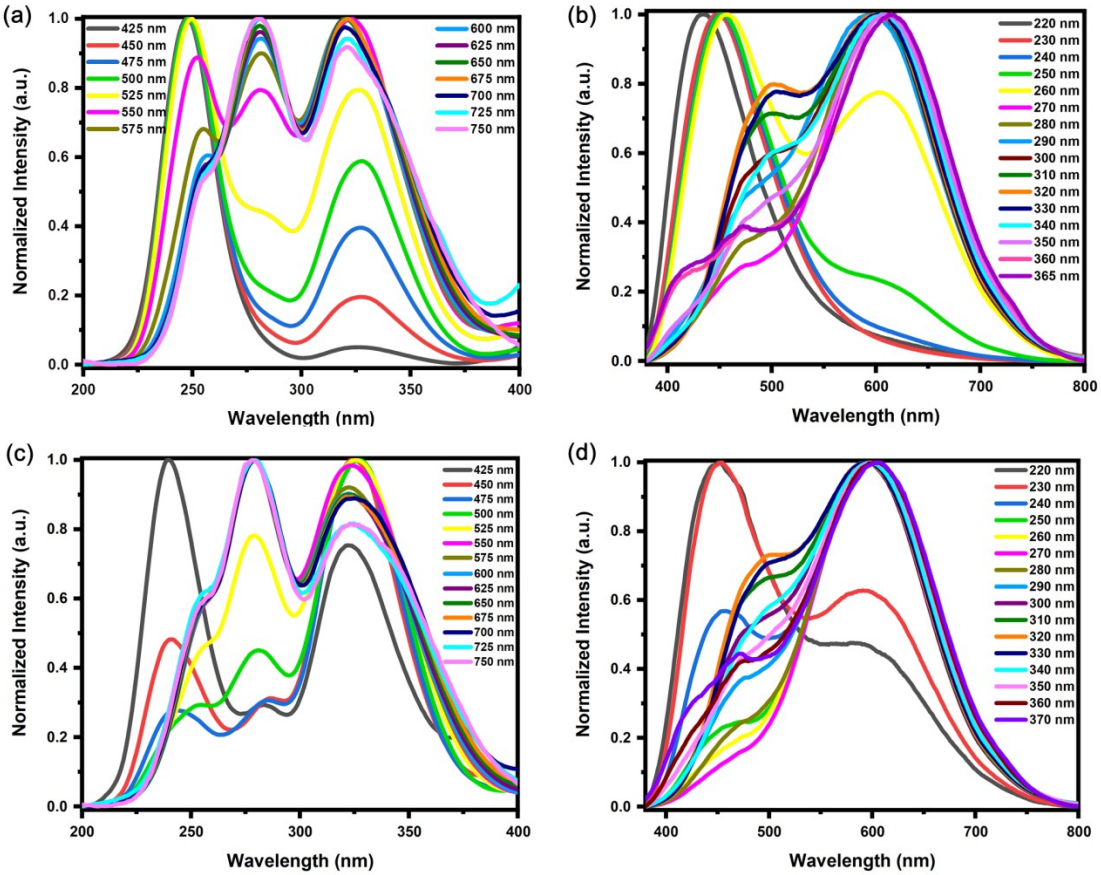

Figure S6. Wavelength-dependent (a) PLE and (b) PL spectra for CHC:0.25%Sb. Wavelength-dependent (c) PLE and (d) PL spectra for CHC:3.76%Sb.

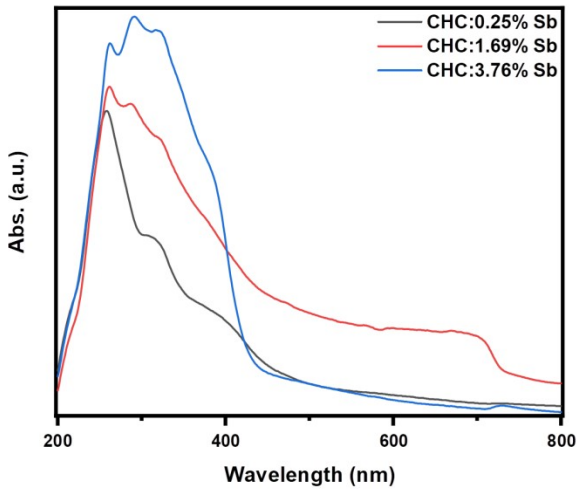

Figure S7. UV-vis absorption spectra of CHC:0.25%Sb, CHC:1.69%Sb and CHC:3.76%Sb.

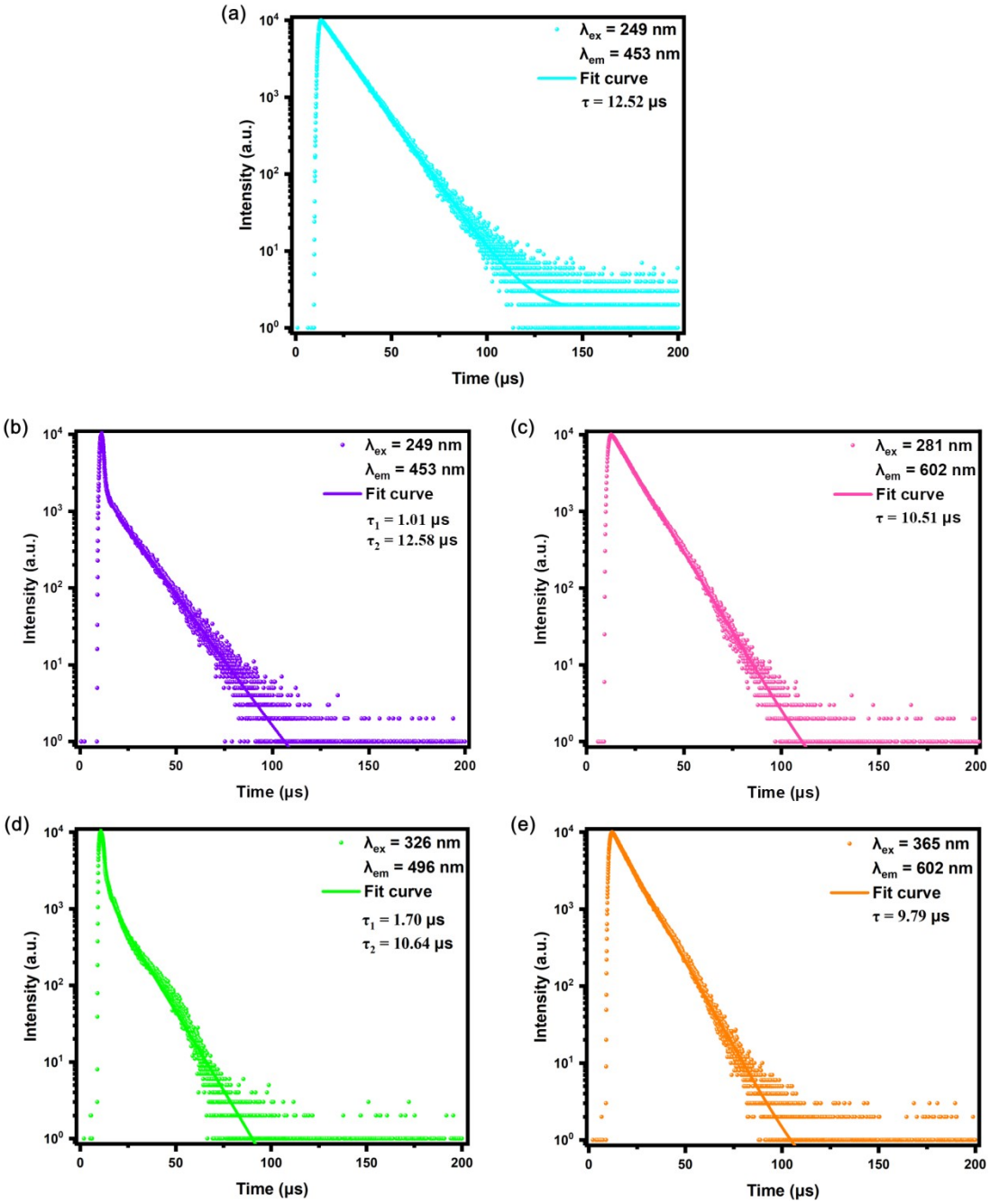

Figure S8. (a) PL decay curve of pure CHC. (b-d) PL decay curve of CHC:1.69%Sb under different test conditions.

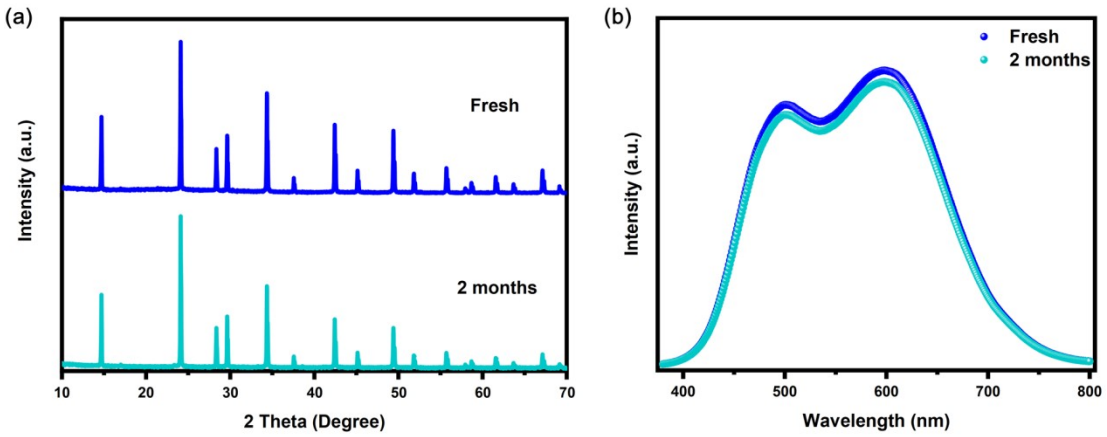

Figure S9. (a) XRD pattern and (b) PL spectra after 2 months of air exposure for CHC:1.69%Sb.

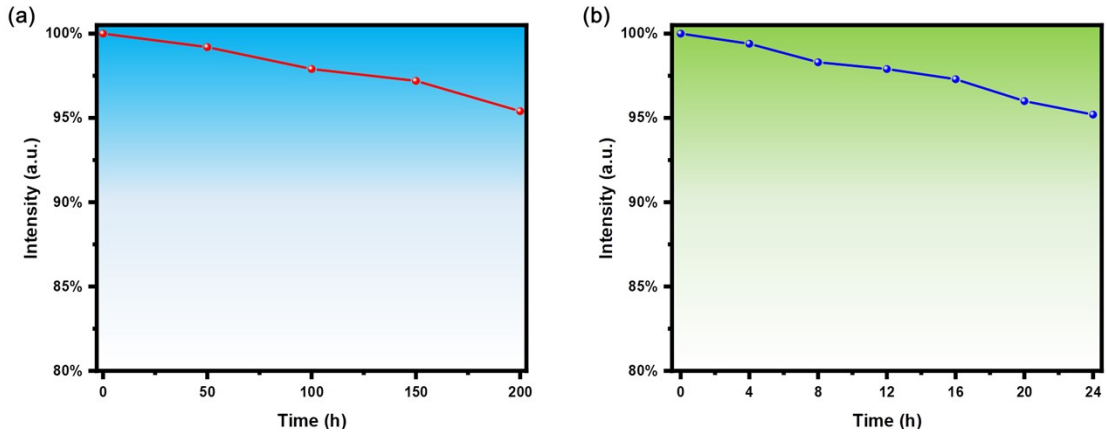

Figure S10. (a) PL intensity of CHC:1.69%Sb under continuous illumination of UV light for 200 hours. (b) PL intensity of LED devices continue to work for 24 hours.

Table S1. Experiment feed ratio and ICP-OES test results of Sb/(Hf + Sb).

Experiment feed ratio	ICP-OES
1%	0.25%
3%	0.83%
6%	1.69%
9%	2.43%
12%	3.76%

Table S2. PL lifetime of CHC:1.69%Sb with different test conditions.

Condition	τ_j
249 nm and 453 nm	1.01 μs (32.79%) 12.58 μs (67.21%)
281 nm and 602 nm	10.51 μs
326 nm and 496 nm	1.70 μs (48.31%) 10.64 μs (51.69%)
365 nm and 602 nm	9.79 μs

Table S3. The CIE coordinate with different excited wavelength for CHC:6%Sb.

Wavelength	CIE
220 nm	(0.22, 0.21)
230 nm	(0.21, 0.21)
240 nm	(0.27, 0.26)
250 nm	(0.38, 0.35)
260 nm	(0.44, 0.40)
270 nm	(0.47, 0.43)
280 nm	(0.45, 0.41)
290 nm	(0.43, 0.40)
300 nm	(0.41, 0.41)
310 nm	(0.40, 0.41)
320 nm	(0.39, 0.41)
330 nm	(0.38, 0.41)
340 nm	(0.41, 0.42)
350 nm	(0.43, 0.42)
360 nm	(0.45, 0.39)
370 nm	(0.46, 0.39)