Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supporting Information

Stable white photoluminescence from Mn-contained organic lead bromide perovskite ring arrays formed from 2D colloidal crystal templates

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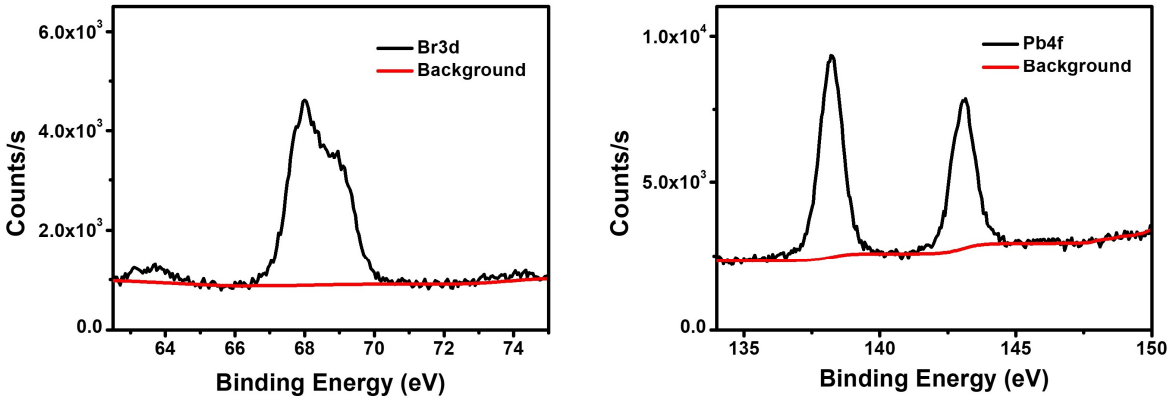

Fig. S1 Narrow-scan XPS results for Br and Pb of $C_4N_2H_{14}PbBr_4$ perovskite ring array.

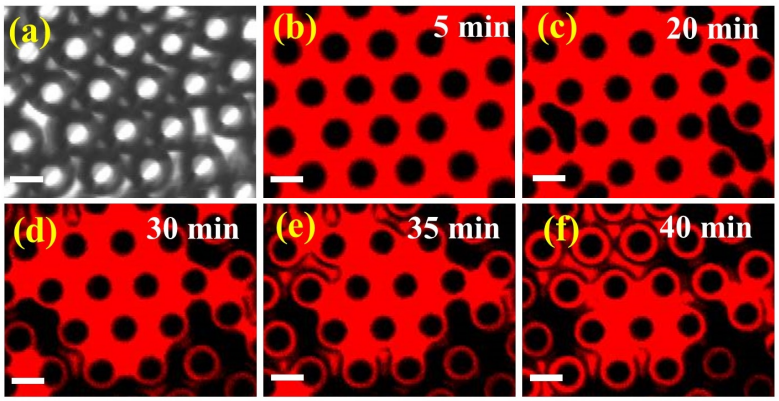

Fig. S2 (a) The micrograph of PS spheres under the bright field. (b-f) The CLSM images at different drying times after spin-coating the mixture solution on the PS microspheres template. The excitation laser was 488nm and photons with wavelengths ranging from 500-550nm were collected. The drying process of the solvent was carried out at room temperature in the open air. The scale bar is 5 μm.

Since there is no photoluminescence for the perovskite precursors (namely $C_4N_2H_{14}Br_2$, $PbBr_2$, and $MnBr_2 \cdot 4H_2O$ in DMSO), and this CLSM is not equipped with 350nm excitation laser, the perovskite ring formation cannot be monitored directly. Therefore, luminescent rhodamine 6G was added into the perovskite precursors solution before CLSM imaging from the bottom of the transparent substrate. As shown in Fig. S2, the contact area between the PS microspheres and the substrate is displayed as the black field, while the mixture solution of perovskite precursors and rhodamine 6G displayed as the red field are evenly spread on the residual space after spin coating. Note that the red color is not the photoluminescence of the solution, which can be set on the software when measuring. With the evaporation of the solvent, the red field begins to move toward the PS spheres at about 30 min. Then most of the red field focuses on the edges of the PS spheres at 40 min.

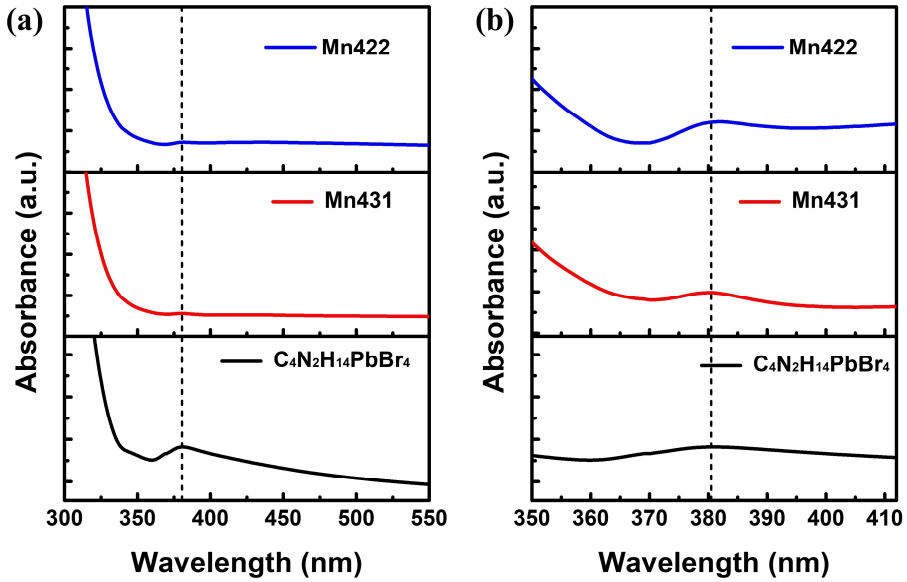

Fig. S3 (a) Absorption spectra and (b) magnified view near the absorption peak (~380 nm) of perovskite ring arrays at different molar feed ratio.

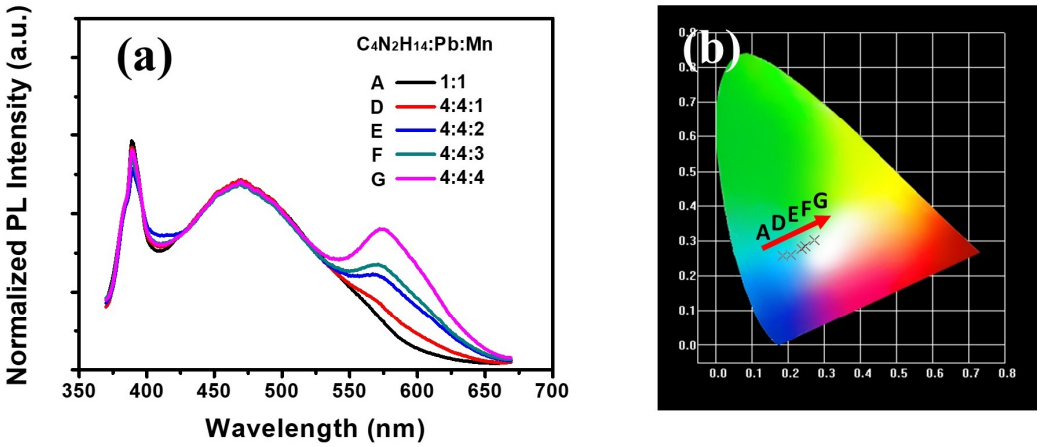

Fig. S4 (a) PL spectra, (b) CIE color coordinates for perovskite ring arrays at different molar feed ratio. The excitation wavelength is 350 nm. The corresponding CIE coordinates are A (0.18, 0.25), D (0.20, 0.26), E (0.23, 0.27), F (0.24, 0.28), G (0.27,0.30).

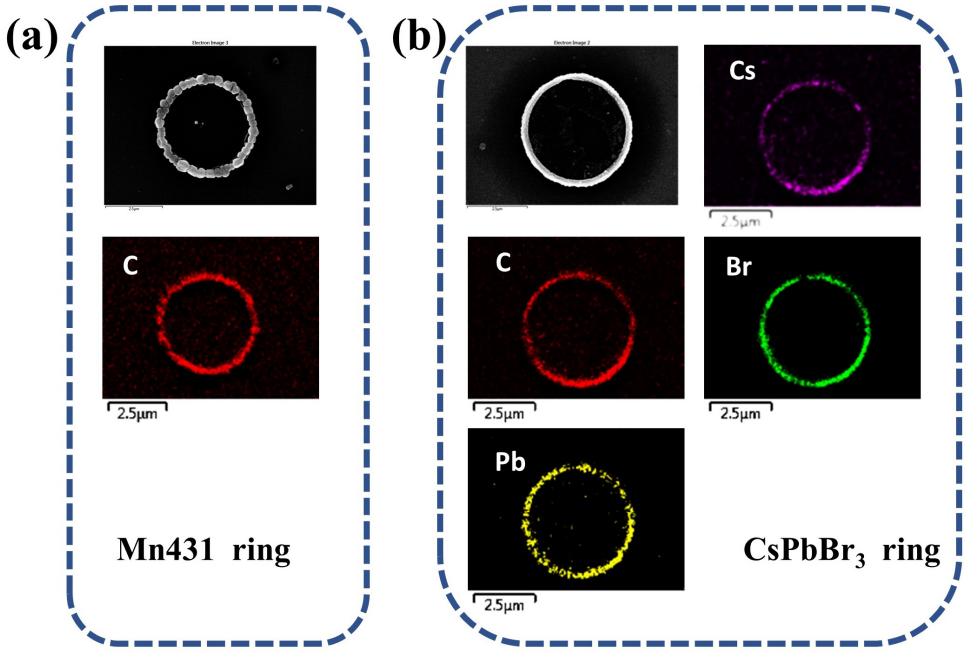

Fig. S5 Scanning electron microscope (SEM) image and the mapping results of (a) Mn431 ring and (b) $CsPbBr_3$ ring.

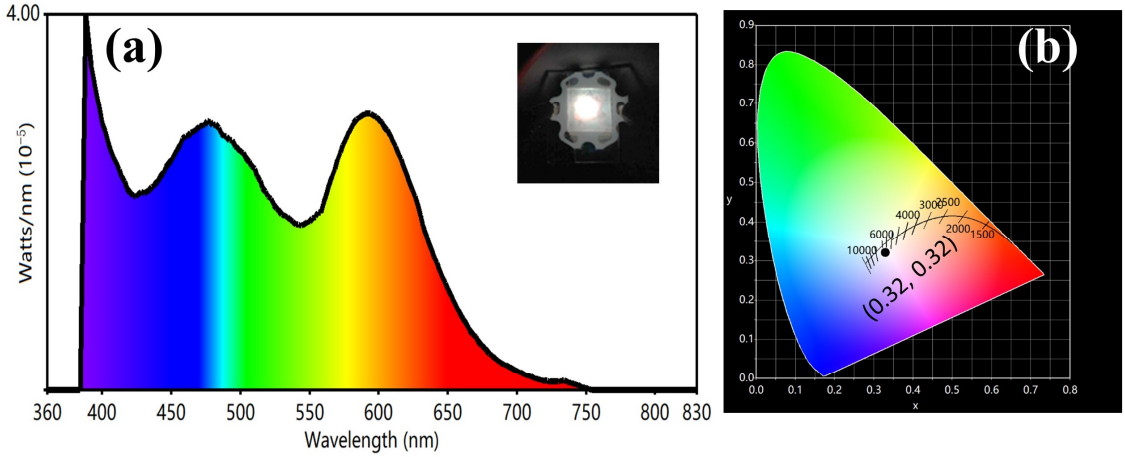

Fig. S6 (a) Radiant power spectra of white light LED with CCT 5645 K (inset is the photograph of the device). (b) CIE coordinates of white light.

As shown in Fig. S5, the intrinsic emission peak of the Mn431 can only be seen after 380 nm. That is because the spectral measurement range of the SpectraScan Spectroradiometer PR-670 is 380-780 nm. The CIE coordinates, CRI, CCT, Duv, LE, and CAF are calculated by integrating between 380 and 780 nm.[1] Therefore, the values of these parameters are not affected by the absence of spectral data before 380 nm.

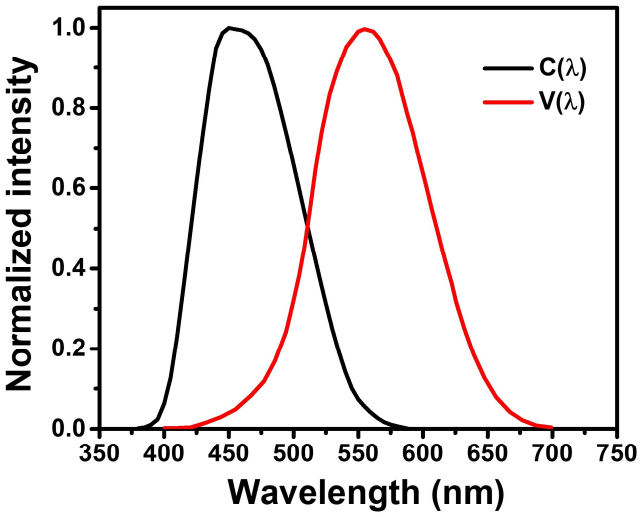

Fig. S7 The spectral luminous efficiency function (V(λ)), and spectral circadian efficiency function (C(λ)). [3]

To well characterize the non-visual biological effects of the white light source inconvenience, Berman has combined melatonin suppression spectra with the spectral luminous sensitivity function and has proposed an impact factor, namely the circadian action factor (CAF).[2] The CAF was calculated using the method proposed by Gall et al.[3] as the following:

$$CAF = \frac{K_C \int_{380}^{780} P(\lambda) C(\lambda)\, d\lambda}{K_m \int_{380}^{780} P(\lambda) V(\lambda)\, d\lambda}$$

Where V(λ) is the photopic spectral luminous efficiency function and C(λ) is the circadian spectral sensitivity function (Fig. S6). Among several suggested C(λ)s in previous reports,[3-7] we used the circadian spectral sensitivity function from Gall *et al*. in this experiment. K_m is the maximal spectral luminous efficacy for vision and K_C is the circadian efficacy value for a non-visual system (K_m=683 lm/W and K_C=683 blm/W, see Ref. 4), respectively.

References

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