Supporting information

Wash-induced Multicolor Tuning in Carbon Nano-dot/Micro-belt Hybrids with Full Recyclability and Stable Color Convertibility

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Experimental Section

Materials

Anhydrous oxalic acid (CA, ≥97%) and octadecene (ODE, ≥90%) are purchased from Tiexi (Shanghai) chemical industry development. Polydimethylsiloxane (PDMS) is purchased from Shanghai JIDE Commercial Trading Company. Chloroform (≥99.0%) and acetone (≥99.5%) are purchased from Shanghai Lingfeng Chemical Reagent Corporation. Ethanol (≥99.7%) is purchased from Wuxi City Yasheng Chemical Corporation. Dialysis bag (200 Da) is purchased from MYM Biological technology Company. UV LED chip is purchased from Guangsheng Semiconductor Company.

Preparation of hybrid carbon emitters

The carbon emitters are prepared by a thermal treatment of a mixture of carbon source and surface passivator in a three-neck flask. Typically, a mixture of 15 ml octadecene (ODE) and 1.5 g of 1-hexadecylamine (HDA) loaded in a three-neck flask is heated at 180 °C for 1.5 hours under a nitrogen flow. Subsequently, 1 g of oxalic acid (OA) is slowly poured into the reaction flask and then kept for 3 hours. The resulting solution is cooled down to the room temperature naturally. The obtained products are purified by precipitating with acetone and ethanol for three, five and seven times, respectively. Finally, w-emitter, g-emitter and b-emitter are dried under vacuum rotary evaporation at 65°C.The separation of C-dots and micro-belts from the phosphor solution is completed by dialyzing against chloroform solvent through the dialysis membrane (Da=200) for 10 days. The solvent is changed every 12 hours.

Fabrication of emitter-coated light-emitting devices

25 mg hybrid carbon w-emitter, g-emitter and b-emitter are dissolved in 5 ml chloroform solvent, respectively. Then, the solution is drop-coated onto a UV LED chip comprised of a 380 nm excitation light emitting unit, subsequently followed by a facile heat-solidification for 10 minutes. Finally, the above steps are repeated for 3 times.

Fabrication of C-dots/PDMS-coated light-emitting devices

20 mg C-dots are dissolved in 5 mL chloroform solvent to obtain C-dots solution. Then, blue C-dots solution is mixed well with 0.2 g polydimethylsiloxane (PDMS) for preparation of transparent fluorescent film. Finally, the prepared mixed solution is drop-coated onto a UV LED chip comprising of a 380 nm excitation light emitting unit, subsequently followed by a facile heat-solidification for 6 hours.

Characterization

Transmission electron microscopy (TEM) images are taken on a HITACHI 7605 microscope and the high resolution transmission electron microscopy (HRTEM) images are taken on a JEOL 2100F microscope. The morphology of the hybrid carbon emitters are measured by scanning electron microscope (SEM, JSM 7800F). The micro-belts are observed on an inverted microscope (TiU, Nikon) with a 60x objective (NA=0.9, Nikon). A laser beam is focused onto micro-belts for excitation and all spectra are recorded with a spectrometer (iHR 550, Horiba) equipped with a cooled charge-coupled device (CCD) camera (Syncerity, JHY). The laser beam is provided by a 405 nm laser (MDL-III-405-100mW, CNI Laser). The Photoluminescence (PL) spectra are recorded by a Fluorescence Spectrometer (F-4600) and UV-Vis absorption spectra are measured with a Shimadzu UV-1750 spectrophotometer. X-ray photoelectron spectroscopy (XPS, Thermo escalab 250Xi) is used to confirm elements and chemical composition of C-dots. Fourier Transform Infrared Spectroscopy (FTIR, DT-40) spectra are measured by neat on a KBr plate. The quantum yields (QYs) of C-dots are measured by fluorescent life test system (American PTI). The related photoelectric parameters of LEDs are measured by a spectrophotometer (PR-745).

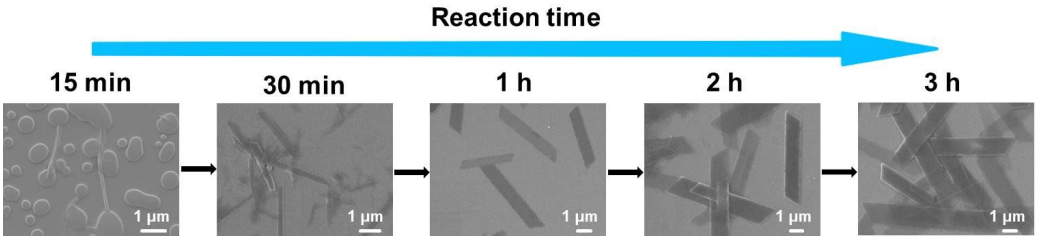


Fig. S1 SEM images of emitters at different reaction time.

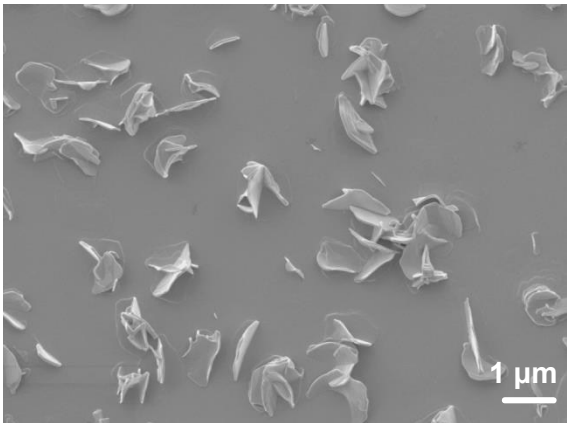


Fig. S2 SEM image of products from HDA under the same hydrothermal treatment without the participation of OA.

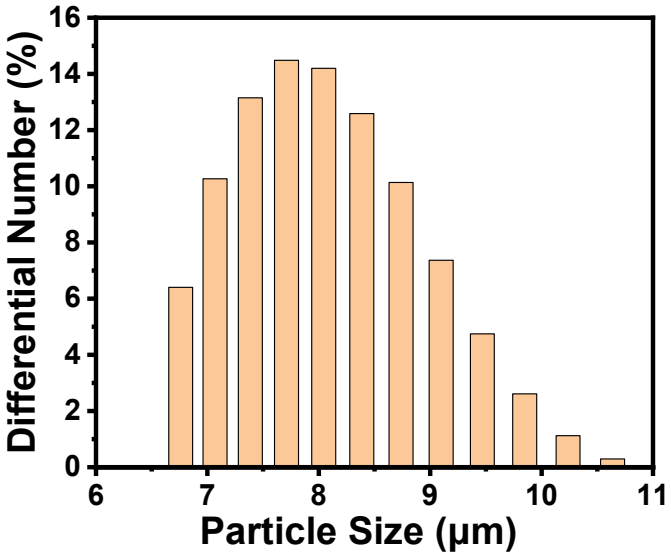


Fig. S3 Particle size distribution measured by dynamic light scattering (DLS).

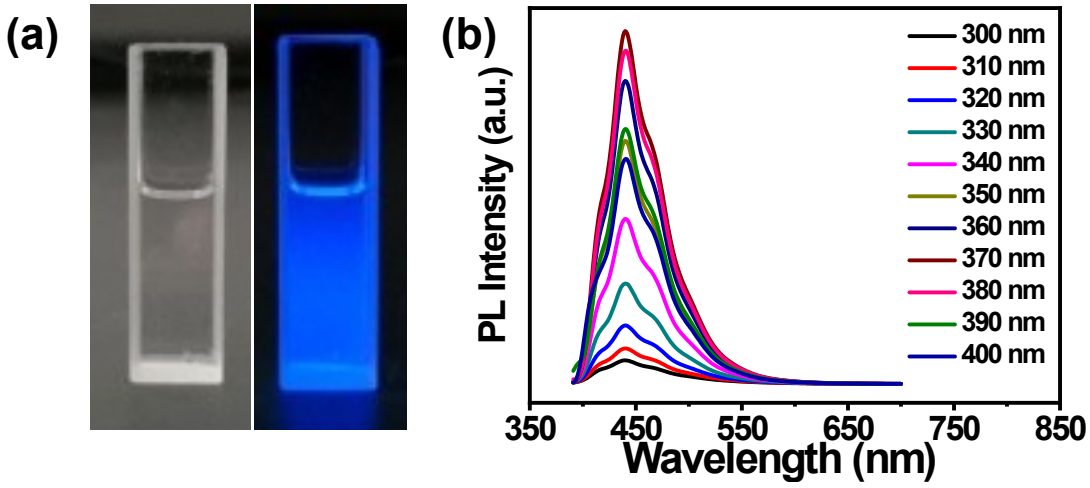


Fig. S4 (a) The optical images of hybrid carbon emitters under daylight (left) and UV irradiation (right). (b) The PL spectra of hybrid carbon emitters

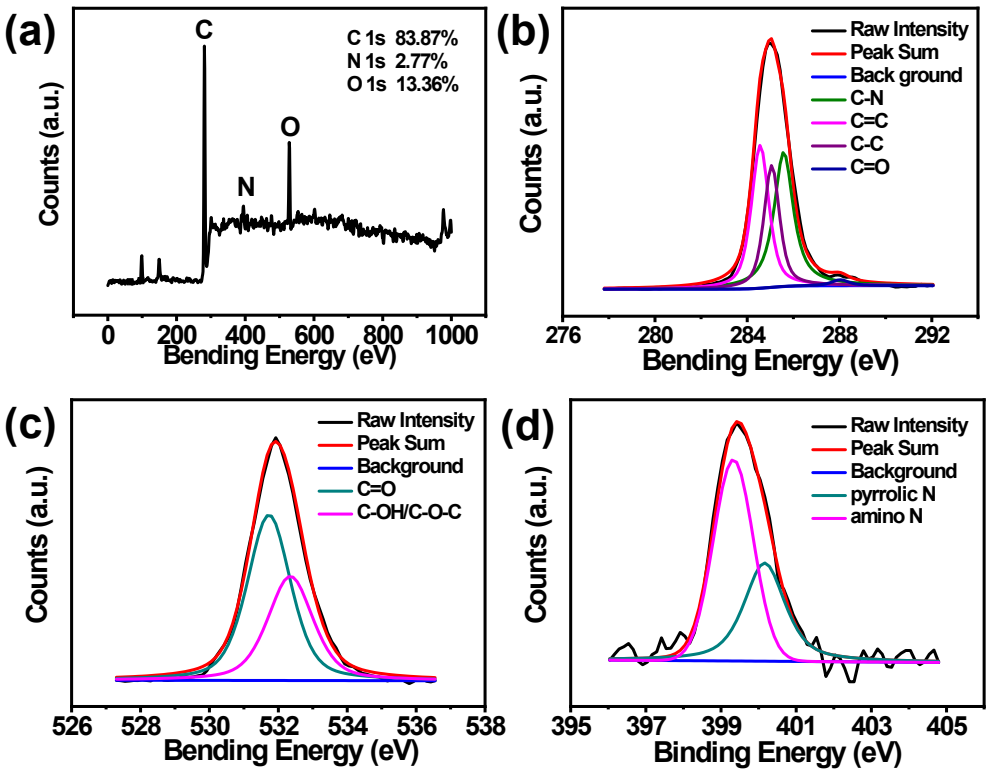


Fig. S5 (a) XPS spectra of the as-prepared C-dots. (b-d) Detail C 1s, O1s, and N 1s of the sample.

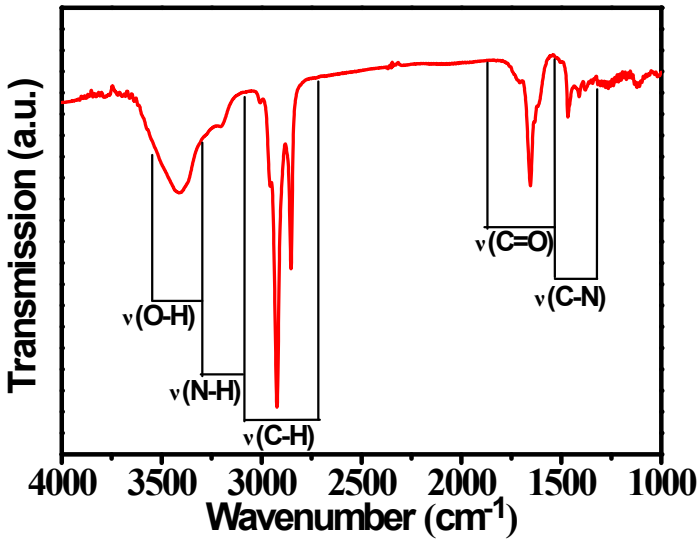


Fig. S6 FT-IR spectra of obtained C-dots.

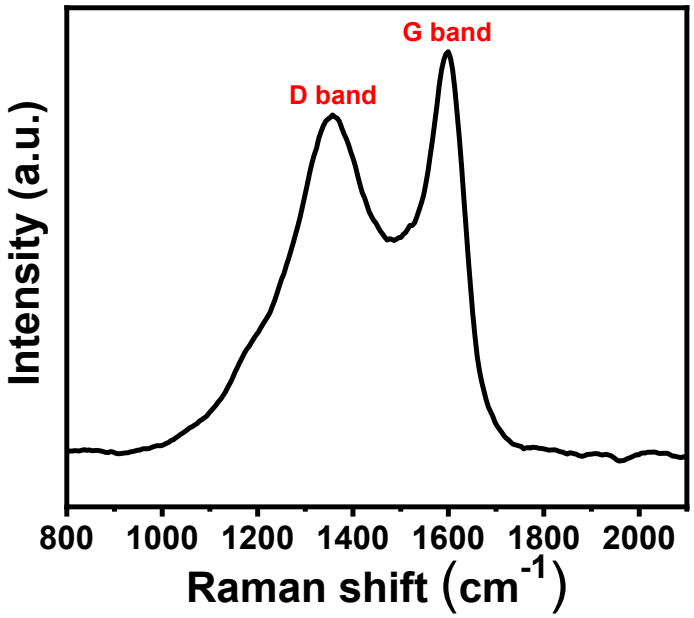


Fig. S7 Raman spectra of C-dots.

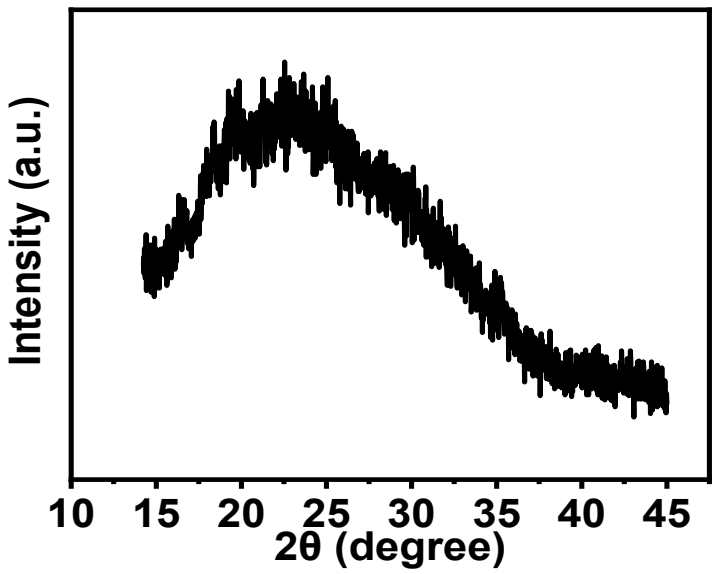


Fig. S8 XRD pattern of C-dots.

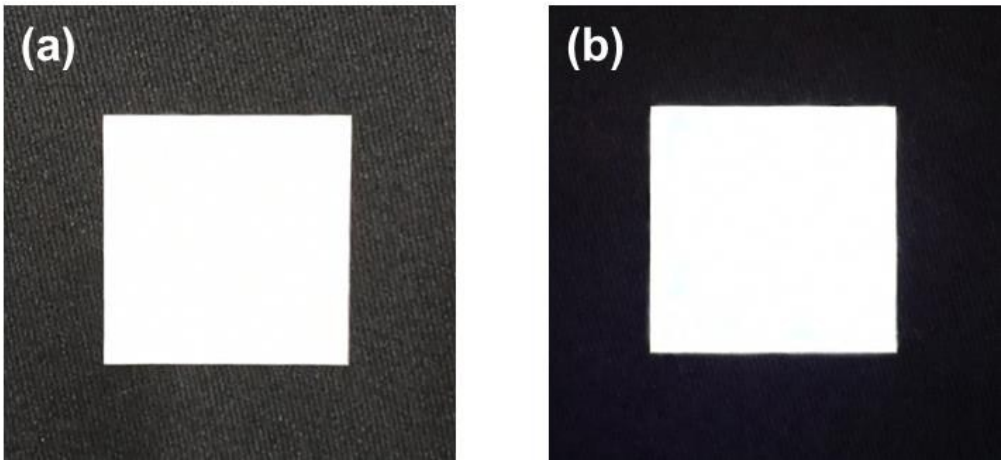
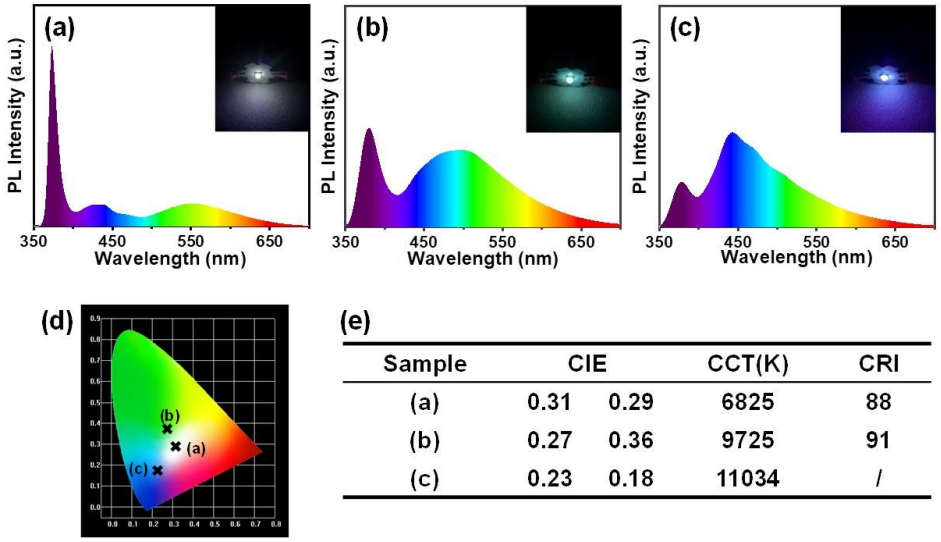


Fig. S9 Photographs of films under daylight (a) and UV light (b) on the glass substrates.



(e)

Sample	CIE		CCT(K)	CRI
(a)	0.31	0.29	6825	88
(b)	0.27	0.36	9725	91
(c)	0.23	0.18	11034	/

Fig. S10 (a-c) The EL spectra of the w-emitter, g-emitter and b-emitter coated LEDs. The inset shows the digital image of the device. (d) The corresponding CIE chromaticity diagram. (e) The parameters of the three emitters coated LEDs.

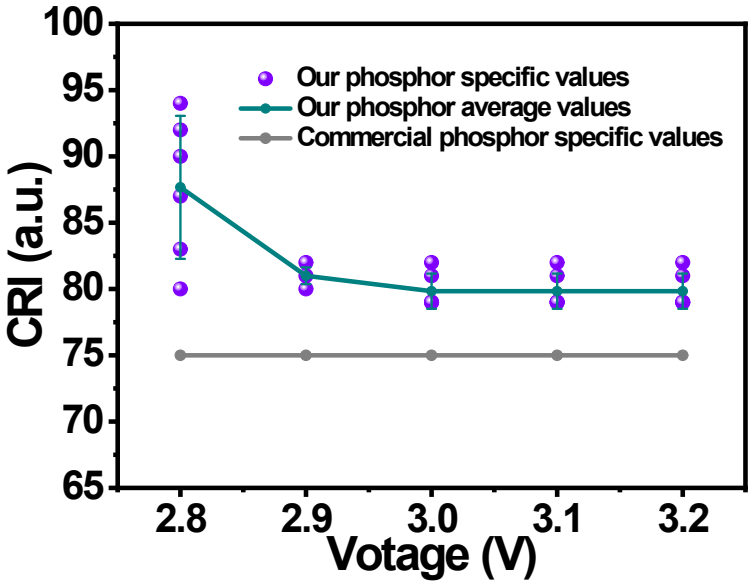


Fig. S11 The CRI spectra of w-emitter and commercial emitter under different voltages.

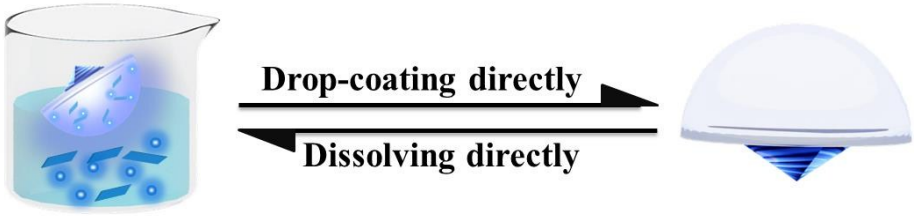


Fig. S12 Schematic illustration of the recycling process of nanocarbon emitters for WLEDs.

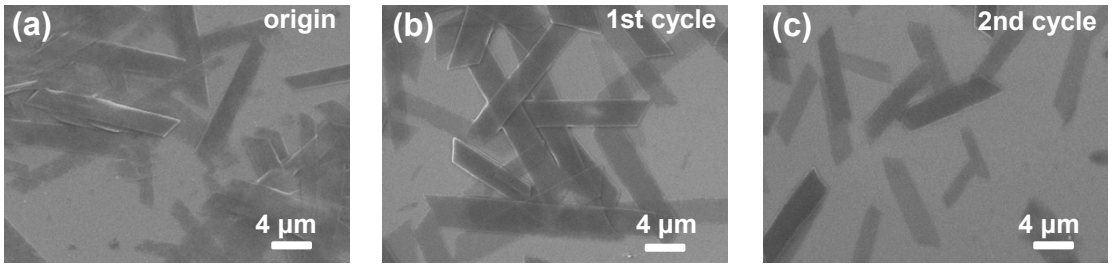


Fig. S13 SEM images of recyclable carbon emitters for two times recycling use in the same concentration.

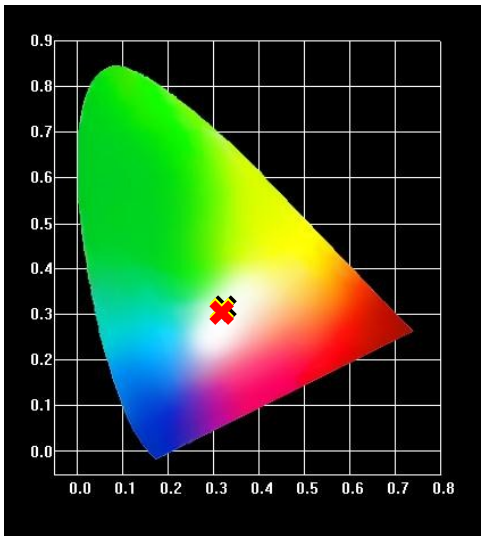


Fig. S14 The corresponding CIE of three emitter-coated WLEDs for recyclable use.

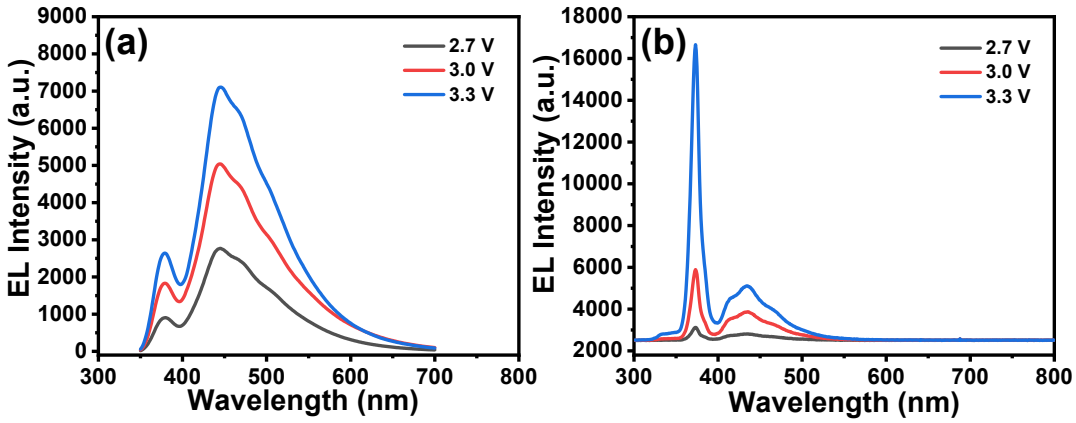


Fig. S15 (a) The EL spectra of C-dots @ micro-belts emitter coated UV LED (380 nm) under different voltages. (b) The EL spectra of C-dots @ PDMS emitter coated UV LED (380 nm) under different voltages.