Electronic Supplementary Information

Photophysics and Electroluminescence of Red Quantum Dots Diluted in a Thermally Activated Delayed Fluorescence Host

Yepeng Xiang,[a,b] Guohua Xie,[a] Manli Huang,[a] Chuluo Yang*[a,b]*

Y. Xiang, Prof. G. Xie, M. Huang and Prof. C. Yang

[a] Renmin Hospital of Wuhan University, Department of Chemistry, Hubei Key Lab on Organic and Polymeric Optoelectronic Materials, Wuhan University, Wuhan 430072, People's Republic of China

E-mail: guohua.xie@whu.edu.cn, clyang@whu.edu.cn

Y. Xiang and Prof. C. Yang

[b] Shenzhen Key Laboratory of Polymer Science and Technology, College of Materials Science and Engineering, Shenzhen University, Shenzhen 518060, China

General information

Materials All materials were used as received without further purification. Red CdSe/ZnS QDs (core/shell-type) octane solution was purchased from Mesolight. The poly(4-styrenesulfonic acid) (PSSA) solution (18 wt.% in H_2O, d = 1.11 g/mL at 25 °C, Mw ~75,000 g/mol) was purchased from Sigma-Aldrich (CAS: 28210-41-5). The PEDOT:PSS (Heraeus Clevios P VP AI 4083) solution, host material of 1,3-bis(carbazol-9-yl)benzene (mCP) and electron injecting material lithium 8-hydroxyquinolinolate (Liq) were purchased from Xi'an Polymer Light Technology

Corporation. The m-PEDOT:PSS solution was simply prepared by mixing 11.1 ul PSSA solution per 100 ul pristine PEDOT:PSS (Heraeus Clevios P VP AI 4083) solution. The electron transport material of 1,3,5-*tri*(m-pyrid-3-yl-phenyl)benzene (TmPyPB) were purchased from Luminescence Technology Corporation. The TADF dendrimer host materials of 10,10'-(Sulfonylbis(4,1-phenylene))*bis*(2,7-*bis*(3,6-di-tert-butyl-9*H*-carbazol-9-yl)-9,9-dimethyl-9,10-dihydroacridine) (4CzDMAC-DPS) were synthesized by ourselves according to previous work and purified by recrystallization.[25-26]

Device Fabrication The ITO coated substrates were firstly cleaned with acetone and ethanol in an ultrasonic bath, respectively. The substrates were further dried with N_2 flow. After 20 min ultraviolet light-ozone (UVO) treatment in a UV-ozone surface processor PL16 series (Sen Lights Corporation), PEDOT:PSS or poly(4-styrenesulfonic acid) (PSSA) modified PEDOT:PSS (m-PEDOT:PSS) precursor was spin-coated onto the ITO surface at 4000 rpm. Afterwards, the substrate was transferred into a N_2 filled glovebox and then baked at 120 °C for 10 min. Subsequently, the corresponding emitting layer was spin-coated at 1000 rpm, followed with a baking at 100 °C for the pure QD layer or 50 °C for the doped QD layer. The electron transporting layer (TmPyPB), the electron injecting layer (Liq), and aluminum cathode were consecutively evaporated in a vacuum chamber under 10^{-5} mbar. The as-fabricated device was sealed with curable UV resin and then measured in ambient air.

Measurement Current density-voltage characteristics, luminance and the EL spectra were recorded with a Keithley 2400 source meter unit and a Photoresearch SpectraScan PR735 spectrometer. The EQE was calculated from the current density, luminance and EL spectrum, assuming a Lambertian distribution. The transient photoluminescence (PL) spectra were measured

by a single photon counting spectrometer from Edinburgh Instruments (FLS920) with a Picosecond Pulsed UV-LASTER (LASTER377) as the excitation source. The absolute photoluminescence quantum yields (PLQYs) were obtained using a Quantaurus-QY measurement system (C9920-02, Hamamatsu Photonics) and all the samples were excited at 365 nm. UV-Vis absorption spectra were recorded on a Shimadzu UV-2501 recording spectrophotometer with baseline correction. The steady-state photoluminescence spectra were recorded on a Hitachi F-4600 fluorescence spectrophotometer. Atomic force microscopy (AFM) measurements were carried out using a Digita Instrumental DI Multimode Nanoscope IIIa in taping mode. Scanning electron microscopy (SEM) measurements were carried out using a Zeiss SIGMA.

Figure S1. The image of the mCP:25 wt.% QD (left), 4CzDMAC-DPS: 25 wt.% QD (middle) and PVK: 25 wt.% QD (right) solutions.

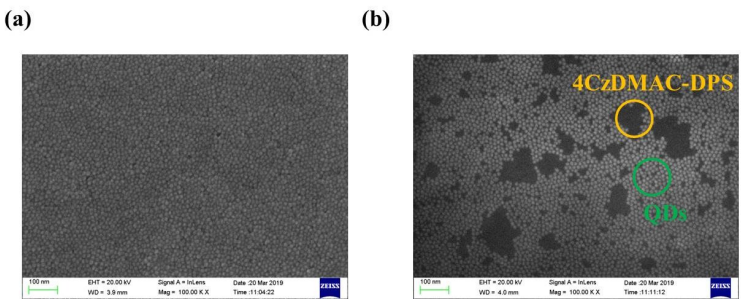

Figure S2. SEM topographic images of (a) pure QD and (b) 4CzDMAC-DPS: 25 wt.% QD films.

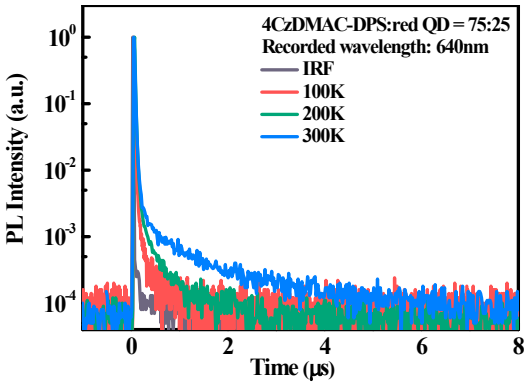

Figure S3. The transient photoluminescence decay spectra of red QD doped into 4CzDMAC-DPS films (25 wt.%) at various temperatures (recorded at 640 nm).

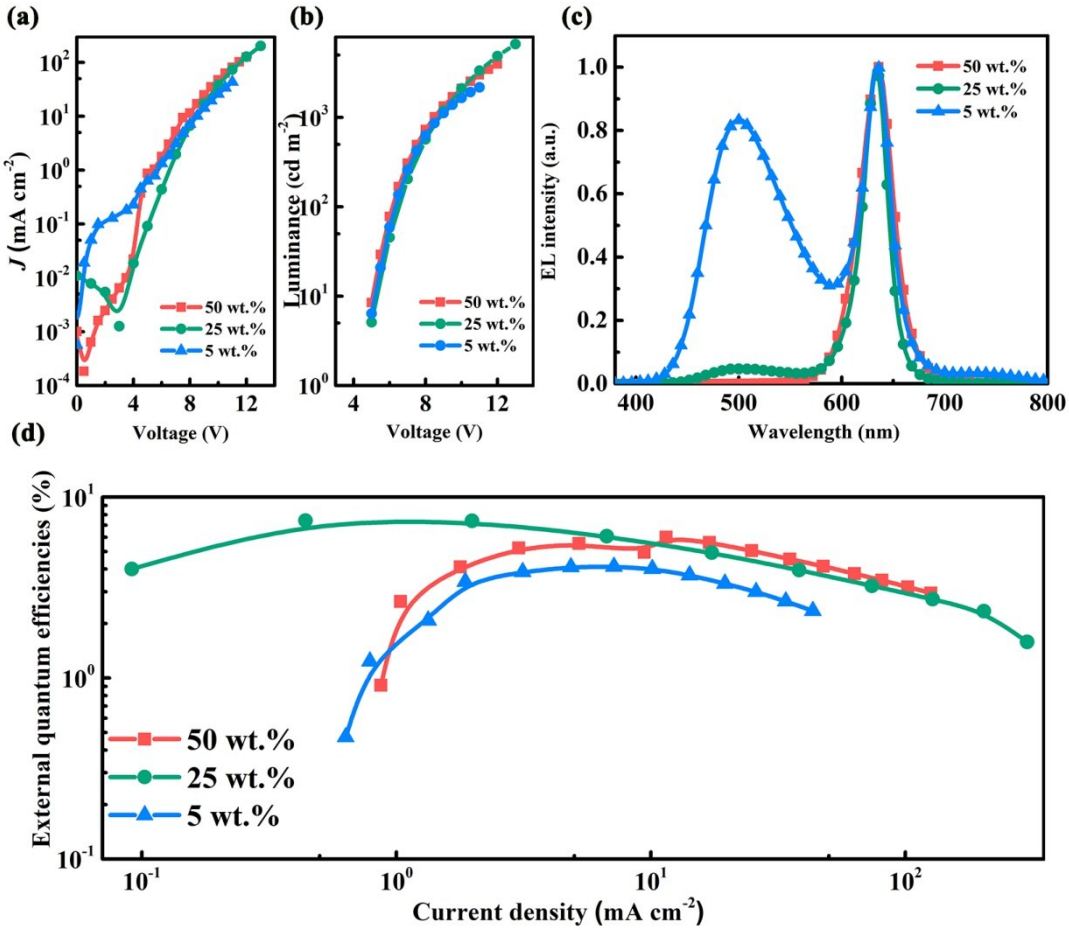

Figure S4. (a) Current density-voltage and (b) luminance-voltage curves of the 4CzDMAC-DPS: QD (X wt.%, X= 5, 25 and 50) based devices. (c) Normalized EL spectra of the devices at a driving voltage of 10 V. (d) External quantum efficiency (EQE) *versus* current density curves of the different QD doping concentration devices.

Table S1. The summary of EL characteristics for devices based on emitting layers with different doping concentrations of red QD in 4CzDMAC-DPS host.

Doping concentration[a] [wt.%]	50	25	5
EQE [%]	6.0	7.4	4.1

[a]The structure of device is ITO/PEDOT:PSS (Heraeus Clevios P VP AI 4083) (~35 nm)/host: QD (X wt.%, X= 5, 25 and 50) (50 nm)/TmPyPB (60 nm)/Liq (1 nm)/Al

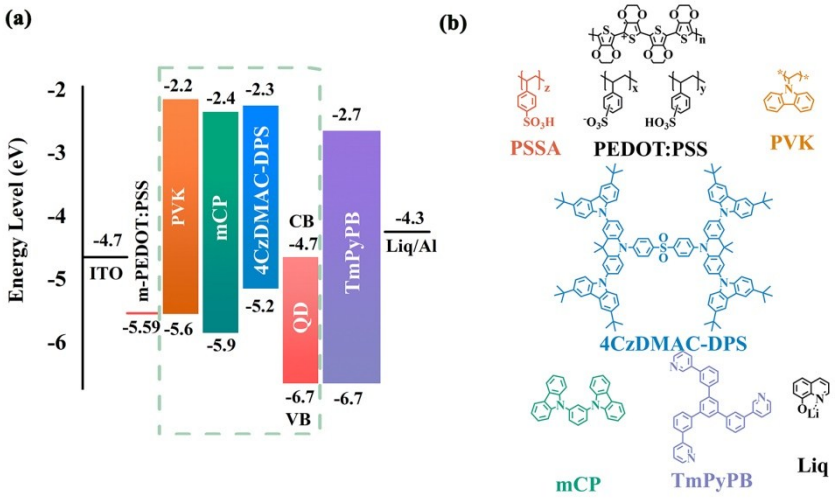

Figure S5. (a) The energy level diagrams and (b) chemical structures of the materials used for the devices 5-8.

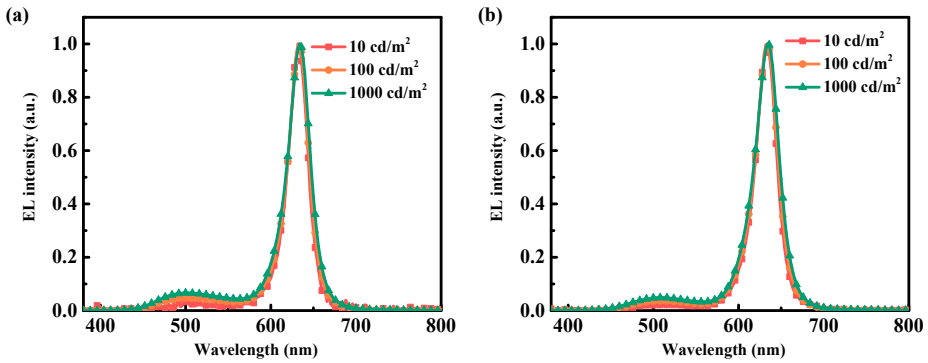

Figure S6. The normalized EL spectra of the 4CzDMAC-DPS involved devices (4 and 8) at various luminances.