

Supporting Information

White Light-Emitting Devices Based on Carbon Dots Electroluminescence

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1. Synthesis of CDs

The CDs was synthesized by carbonizing citric acid in hot noncoordinating solvent. Briefly, a mixture of 15 mL octadecene and 1.5 g 1-hexadecylamine loaded in a three neck flask was heated to 300 °C under argon flow, and then 1 g citric acid was quickly injected into the reaction flask, and then kept at that temperature for 5 min. The

resulting solution was then cooled to room temperature naturally and was further purified by column chromatography, the PL efficiency of the final CDs was around 61% (excited at 360 nm using Quinine sulfate in 0.1 M H₂SO₄ as standard reference).

2. Device Fabrications

Indium-tin-oxide (ITO) coated glass substrates was cleaned ultrasonically in organic solvents (isopropyl alcohol, acetone, and methanol), rinsed in deionized water, and then dried in an oven at 120 °C for more than an hour. The substrate was cleaned with a UV-ozone cleaner prior to spin-coated a thin hole transporting layer (THL) of the poly(3,4-ethylenedioxythiophene) : poly(styrenesulfonate) (PEDOT:PSS). The emission layer of the CDs was then spin-coated from a solution of toluene onto the THL to form a 20±5 nm thick film, and further baked at 150 °C for 1 h. A 40 nm thick electro transporting layer (ETL) of TPBI, 1 nm thick LiF, and 120 nm thick Al electrodes were deposited under a base pressure of 3×10⁻⁶ Torr by thermal evaporation, and the evaporation speed was 1-1.5 Å/s for TPBI and 4-5 Å/s for the metals.

Our devices were measured without environmental packaging and in atmospheric conditions. Film thickness was monitored by frequency counters and calibrated by a Dektak 6M profiler (Veeco). Current J-V characteristics of the CWLEDs were recorded using a computer controlled Kei-thley 2400 current/voltage source-meter. To calculate the EQEs, the EL from the front face of the device was detected using a calibrated Newport 818-UV silicon photo-detector at the same time that the J-V characteristics were measured. EL spectra were taken with an Acton spectrometer with bias applied to the device using the Kei-thley 2400.

The Fluorescent spectra of the CDs spin coated on silica were record on F-4500 FLRORESCENT SPECTRALMETER. The AFM and fluorescent image of CDs on top of PEDOT:PSS were obtained from a Dimension 3100 with OMCLAC 160 tip (TS-W2, silicon) and Olympus BX 51, BP: 330-385 nm, respectively.

3. Quantum Yield (QY) Measurements.¹

Quinine sulfate in 0.1 M H₂SO₄ (literature quantum yield 0.54 at 360 nm) was chosen as a standard. The quantum yield of CDs in toluene was calculated according to:

$$\varphi_x = \varphi_{std} \left[\frac{I_x}{A_x} \right] \left[\frac{A_{std}}{I_{std}} \right] \left[\frac{\eta_x}{\eta_{std}} \right]^2$$

Where φ is the quantum yield, I is the measured integrated emission intensity, η is the refractive index, and A is the optical density. The subscript “*std*” refers to the reference fluorophore of known quantum yield. In order to minimize re-absorption effects, absorption was kept below 0.05 at the excitation wavelength (360 nm).

4. The Morphology of purified CDs

Fig. S1 shows the TEM image of the purified CDs, the observed result illustrate the CDs are almost spherical dots with diameters around 5 nm.

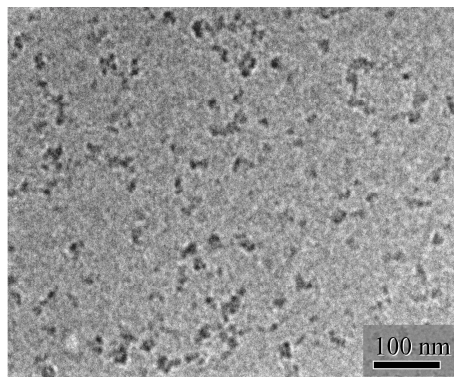


Fig. S1 TEM image of purified CDs.

5. The emission of CDs

The absorption and emission spectra of CDs in toluene are comparable to those previously reported for carbon dots. The emission peaks shift to longer wavelengths with increasing excitation wavelength. The strongest emission is observed for an excitation at 360 nm. See Fig. S2.

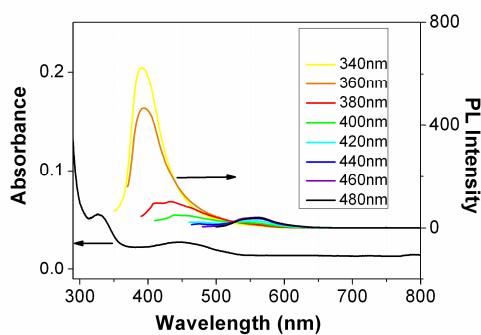


Fig. S2 Absorption and photoluminescence emission spectra of purified CDs in toluene excited at different wavelength.

6. Electrochemical Measurements

The electrochemical cyclic voltammetry was performed for determining the highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO) levels of the CDs.² Electrochemical cyclic voltammetry was conducted on a

CHI 660C electrochemical workstation. The CDs solution in THF containing 0.1 mol/L $[\text{Bu}_4\text{N}]\text{PF}_6$ was measured at a potential scan rate of 100 mV/s at room temperature under the protection of dry Nitrogen. A Pt disk was used as the working electrode. A Pt wire and a saturation calomel electrode (SCE) were used as the counter electrode and reference electrode, respectively.

Fig. S3 shows the cyclic voltammogram of CDs solution in THF. The onset of oxidation potential of the CDs is determined as 0.80 V vs. SCE. The HOMO of the CDs was thus calculated as -5.0 eV according to the equation: $\text{HOMO} = -e(E_{\text{ox, onset}} + 4.741)$ (eV). The LUMO was calculated by the equation: $\text{LUMO} = \text{HOMO} + E_g$.

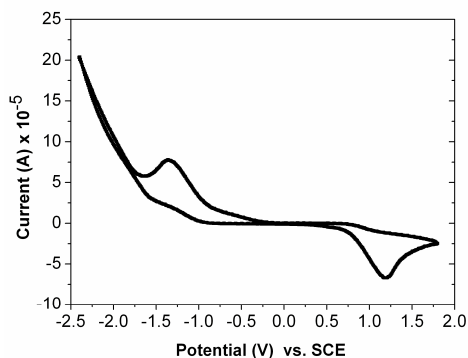


Fig. S3 Cyclic voltammogram of the CDs in THF at a scan rate of 100 mV/s.

References:

1. J. R. Lakowicz, Principles of Fluorescence Spectroscopy, 2nd Ed., 1999, Kluwer Academic/Plenum Publishers, New York.
2. Y. C. Li, H. Z. Zhong, R. Li, Y. Zhou, C. H. Yang and Y. F. Li, *Adv. Funct. Mater.*, 2006, **16**, 1705.