

Electronic Supplementary Information

Direct Blending of Multicolor Carbon Quantum Dots into Fluorescent Film for White Light Emitting Diodes with Adjustable Correlated Color Temperature

Yuanfei Ding,^{a,b} Jingxia Zheng,^{a,b} Junli Wang,^{a,b} Yongzhen Yang,^{*a,b} and Xuguang Liu^{*a,c}

^aMOE Key Laboratory of Interface Science and Engineering in Advanced Materials, Taiyuan University of Technology, Taiyuan 030024, China. E-mail: yyztyut@126.com; liuxuguang@tyut.edu.cn.

^bResearch Center of Advanced Materials Science and Technology, Taiyuan University of Technology, Taiyuan 030024, China.

^cCollege of Materials Science and Engineering, Taiyuan University of Technology, Taiyuan 030024, China.

***Corresponding Author**

E-mail: yyztyut@126.com (Yongzhen Yang).

E-mail: liuxuguang@tyut.edu.cn (Xugaung Liu).

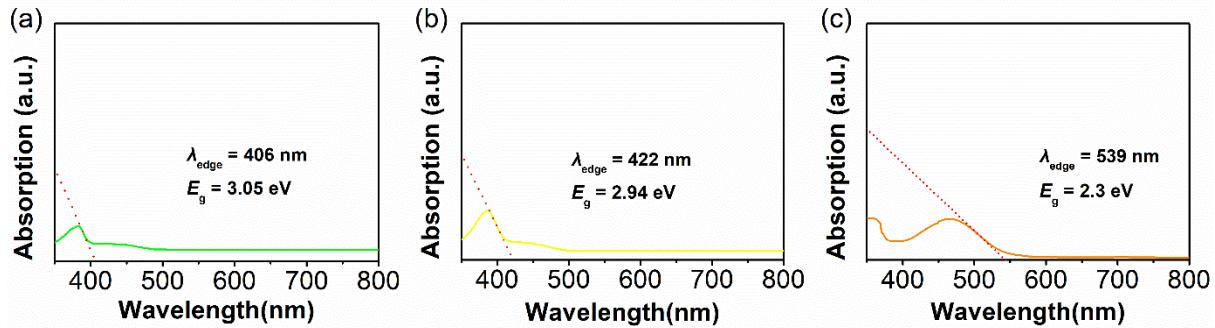


Fig. S1 Determination of band gap energy of G- (a), Y- (b), and O-CQDs (c) from UV-vis spectra.

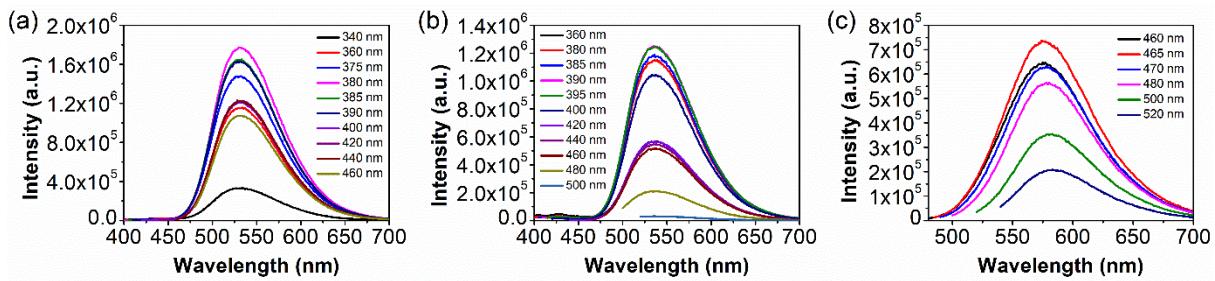


Fig. S2 Fluorescence spectra of G- (a), Y- (b), and O-CQDs (c) at different excitation wavelengths.

Table S1. Fluorescence-decay lifetimes and fitting parameters of G-, Y-, and O-CQDs.

Sample	τ_1	$A_1 (\%)$	τ_2	$A_2 (\%)$	τ_3	$A_3 (\%)$	χ^2	τ_{ave}
G-CQDs	20.74	100	-	-	-	-	1.00	20.74
Y-CQDs	13.35	100	-	-	-	-	1.00	13.35
O-CQDs	2.51	14.56	7.76	46.80	16.74	38.64	1.06	10.46

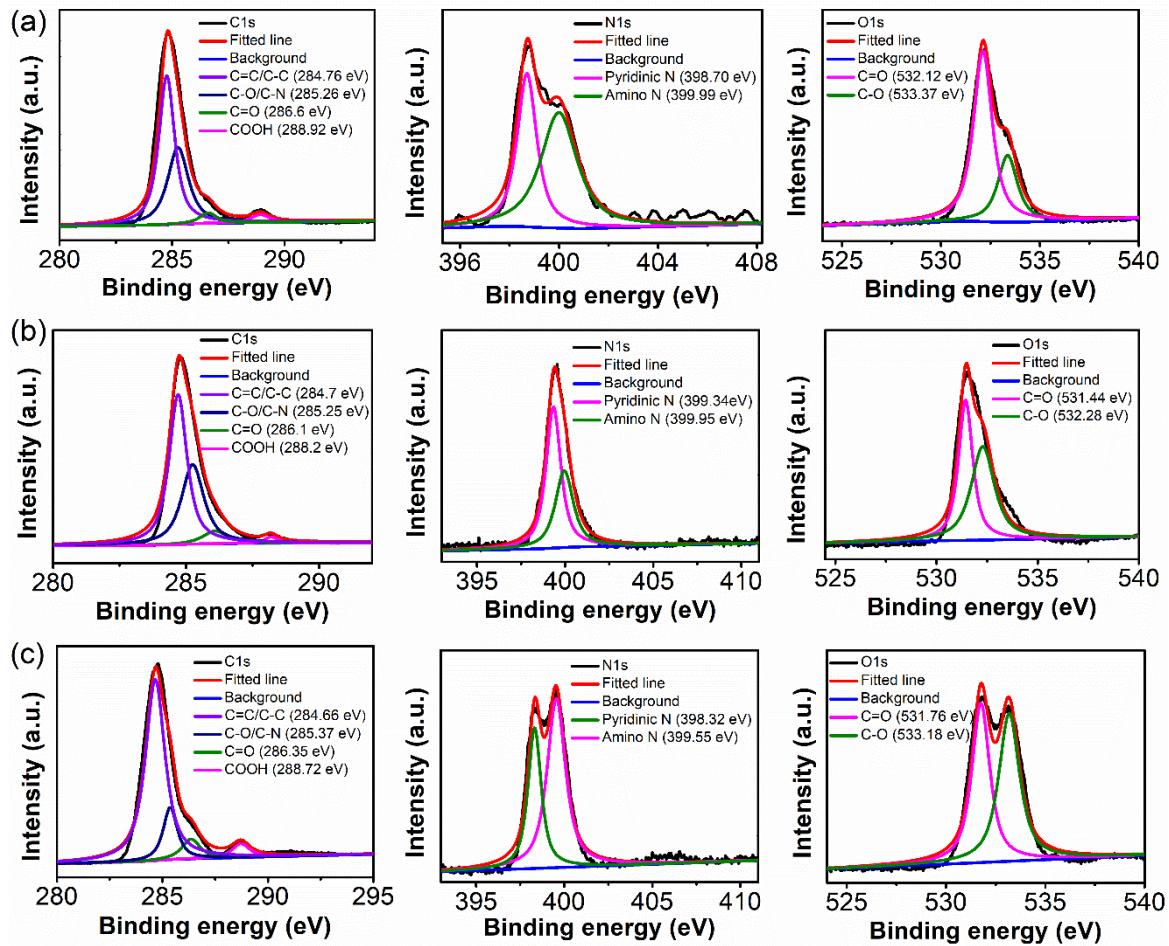


Fig. S3 High-resolution XPS C1s, N1s, and O1s spectra of G- (a), Y- (b), and O-CQDs (c).

Table S2. XPS data analyses of the N1s spectra of G-, Y-, and O-CQDs.

Sample	Pyridinic N (%)	Amino N (%)
G-CQDs	41.78	58.22
Y-CQDs	60.21	39.79
O-CQDs	37.30	62.70

Table S3. The atomic composition of C, N, and O of G-, Y-, and O-CQDs (determined by XPS).

Sample	C (%)	N (%)	O (%)	O/C atomic ratio
G-CQDs	81.31	3.11	15.58	0.19
Y-CQDs	88.76	5.41	5.83	0.07
O-CQDs	80.83	7.88	11.29	0.14

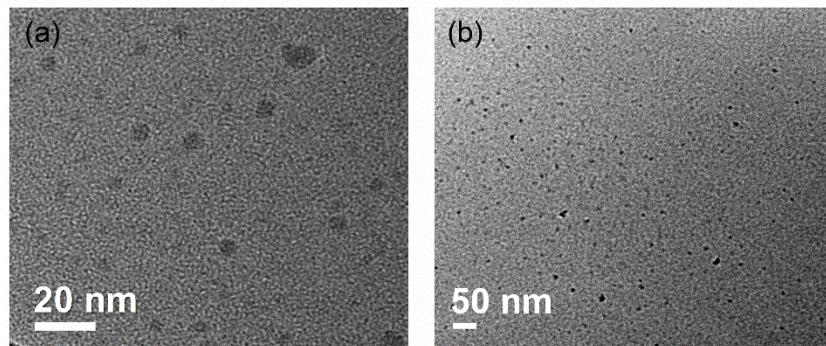


Fig. S4 TEM images of B- (a) and R-CQDs (b).

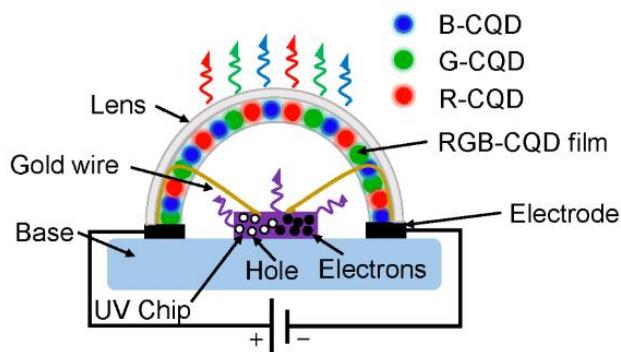


Fig. S5 Schematic diagram of the WLED based on B-, G-, and R-CQD phosphors.

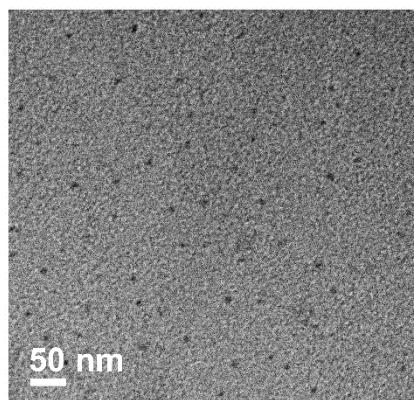


Fig. S6 TEM images of RGB-CQD film.

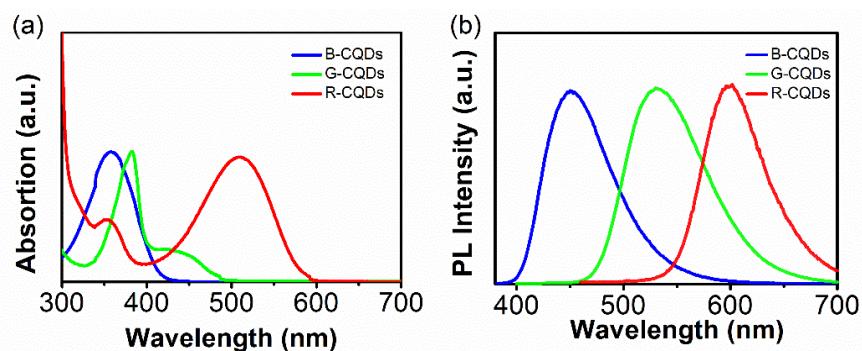


Fig. S7 (a) UV-Vis absorption and (b) PL spectra of R-, G-, and B-CQDs solution.

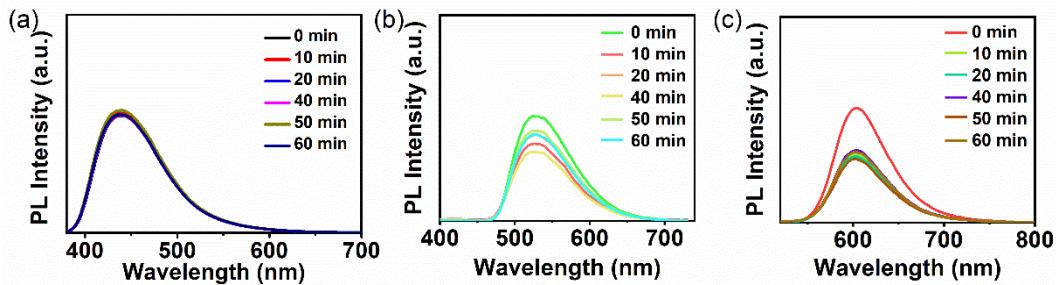


Fig. S8 PL spectra of (a) B- (taken from *J. Mater. Chem. C*, 2017, **5**: 8105-8111), (b) G-, and R-CQDs (c) at different UV light exposure time under UV excitation at 365 nm.

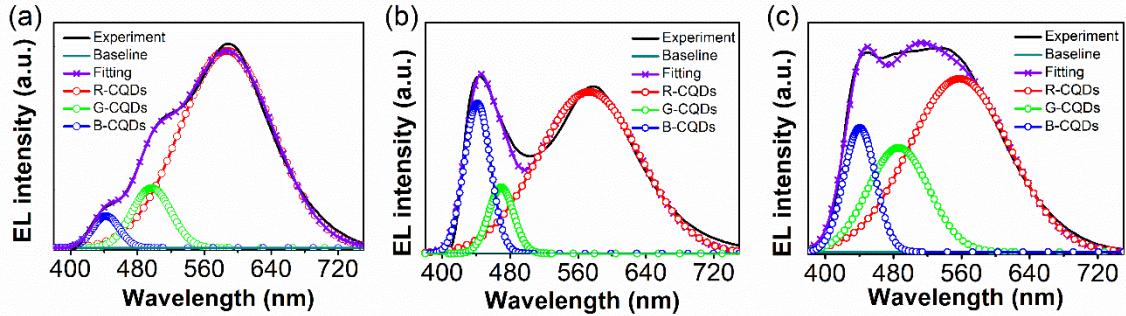


Fig. S9 EL spectra of WLED devices A, B, C, the purple with cross symbols indicate the estimated spectra of total Gaussian fitting, the blue, green, and red indicate the corresponding Gaussian fitting of B-CQDs, G-CQDs, and R-CQDs, respectively.

Table S4. CCT, CIE color coordinates (x, y), CRI, volume ratios (B-CQD solution: G-CQD solution: R-CQD solution), and luminous efficacy of WLEDs A–C.

Device	CCT (K)	CIE (x, y)	CRI	Volume ratio	Luminous efficacy (lm W^{-1})
A	3466	(0.41, 0.41)	83	1.67:1:0.25	2.27
B	5215	(0.33, 0.33)	88	20:1:1	22.17
C	7368	(0.29, 0.34)	84	40:1:0.20	14.85

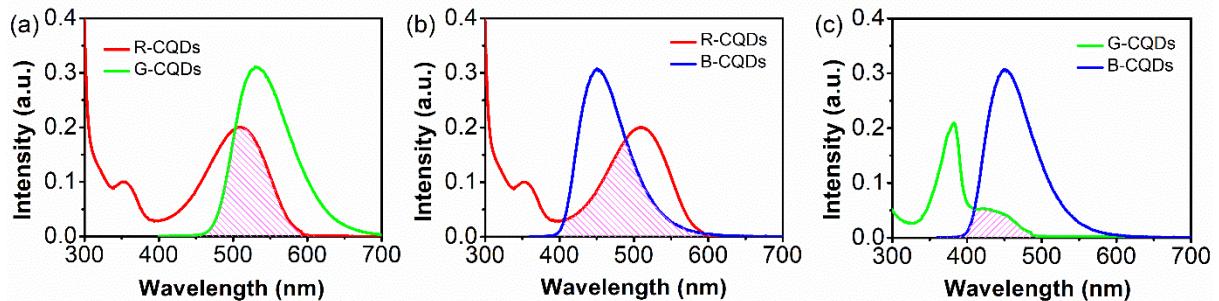


Fig. S10 UV-Vis absorption spectra of R-CQDs and PL emission spectra of G- (a) and B-CQDs (b), (c) UV-Vis absorption spectra of G-CQDs and PL emission spectra of B-CQDs.

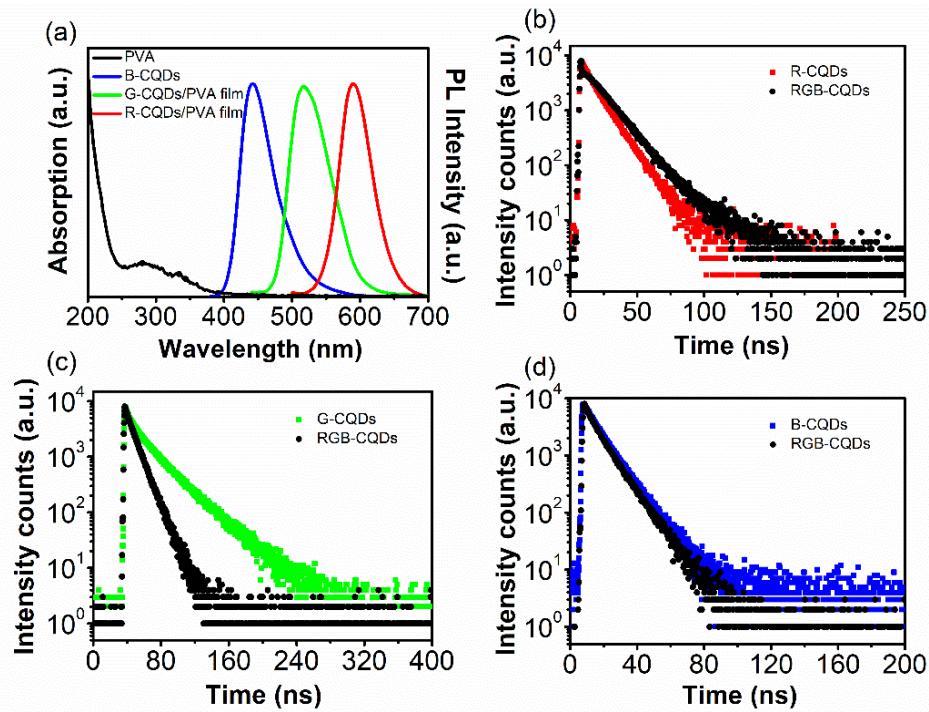


Fig. S11 (a) UV-Vis absorption spectra of PVA and PL spectra of B-CQDs, G-CQD/PVA, and R-CQDs/PVA films. PL decay curves at 375 nm excitation for (b) R-CQDs/PVA film and the fluorescence RGB-CQD film probed at 590 nm, (c) G-CQDs/PVA film and the fluorescence RGB-CQD film probed at 520 nm, and (d) B-CQDs film and the fluorescence RGB-CQD film probed at 443 nm.