nanomaterials

Article

Mesoporous Tungsten Trioxide Photoanodes Modified with Nitrogen-Doped Carbon Quantum Dots for Enhanced Oxygen Evolution Photo-Reaction

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Supporting Information

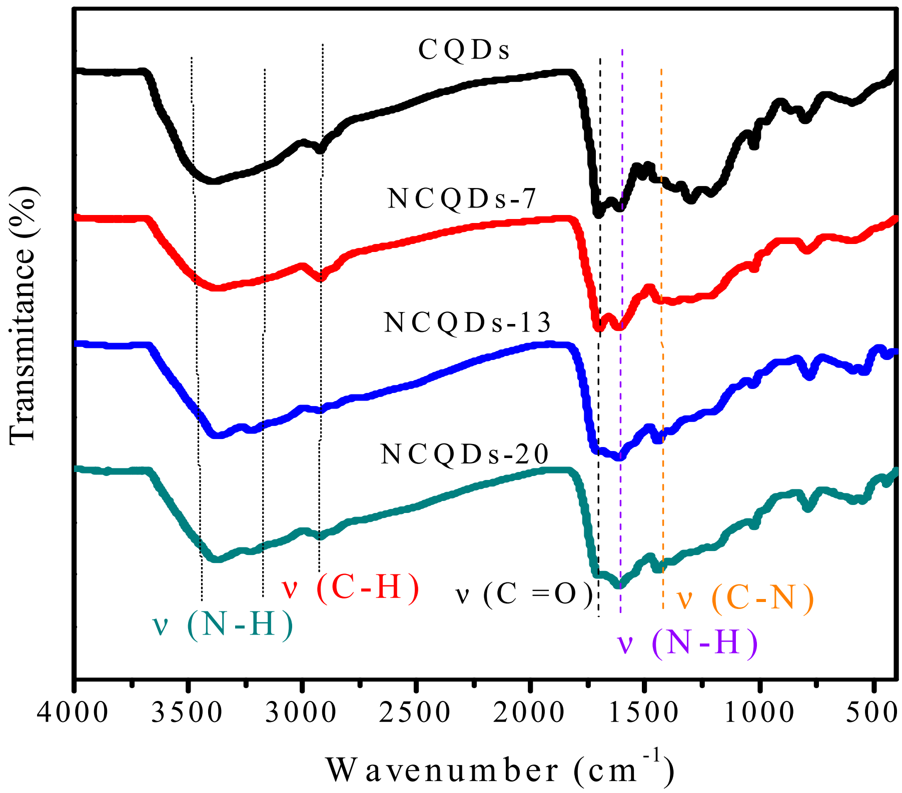


Figure 1. FTIR spectra of CQDs and N-CQDs samples.

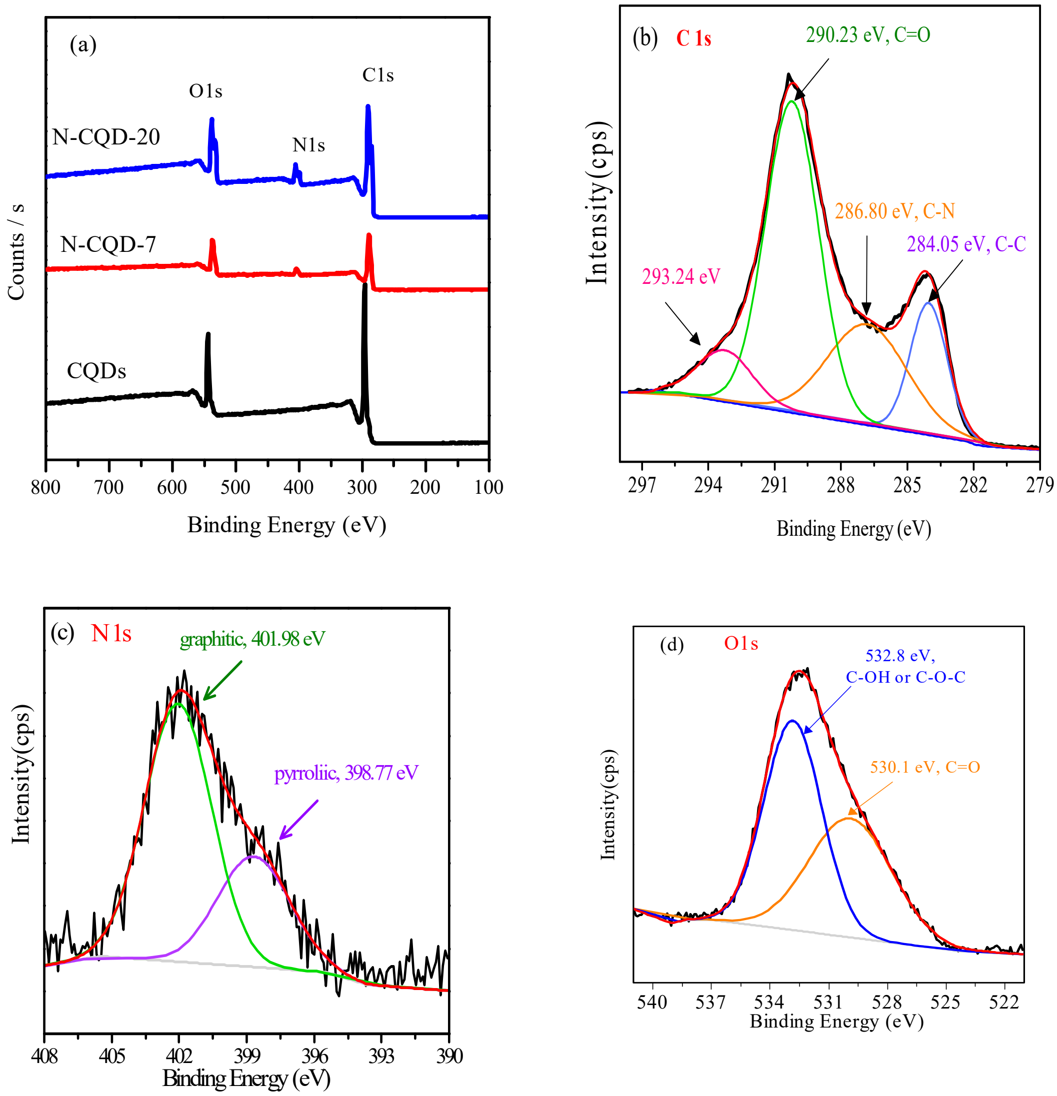


Figure 2. (a) XPS survey spectra for the CQDs, N-CQD-7 and N-CQD-20 samples. The only elements identified were carbon, nitrogen and oxygen. (c) C 1s, (d) N 1s and (E) O 1s high resolution XPS spectra for N-CQD-7 sample.

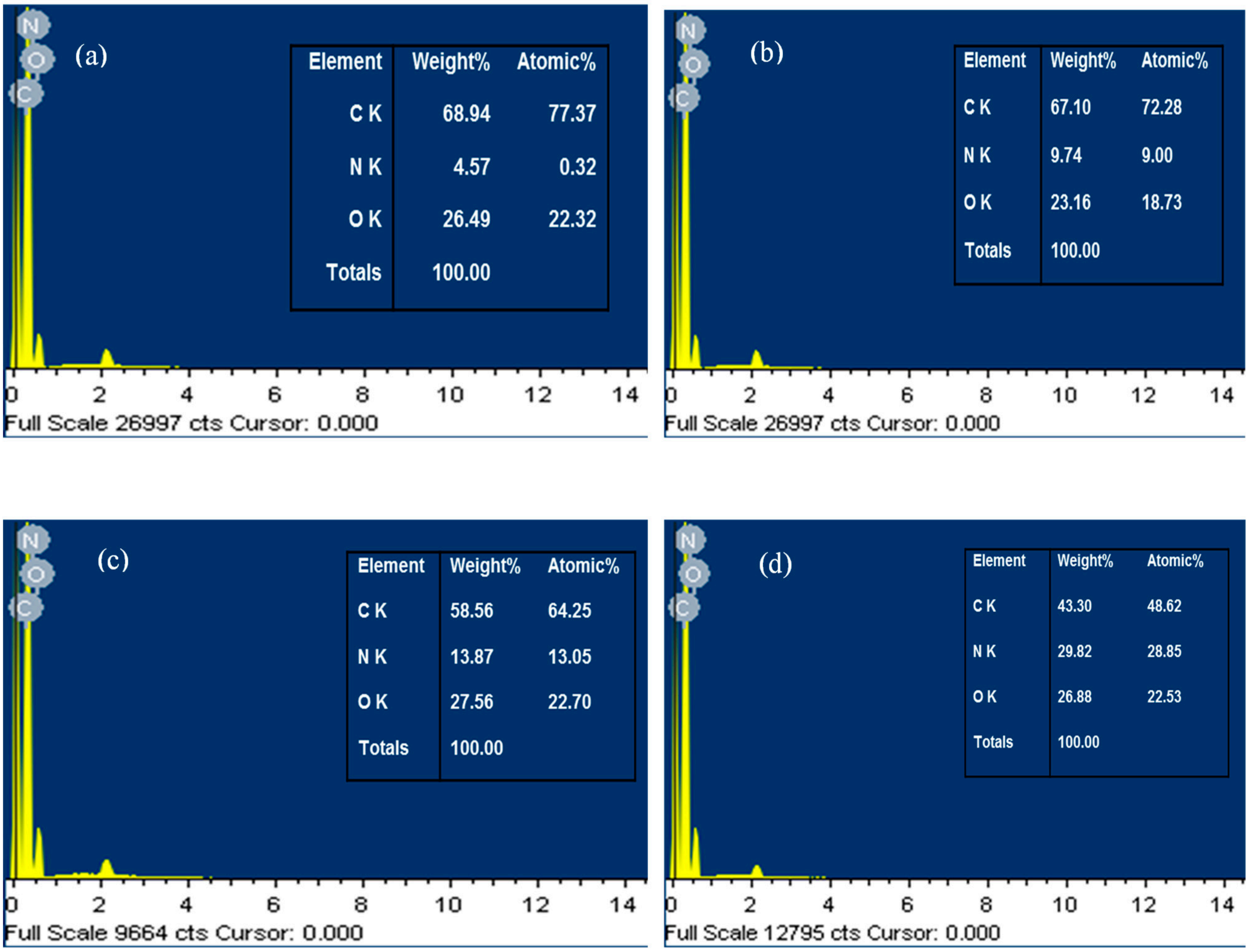
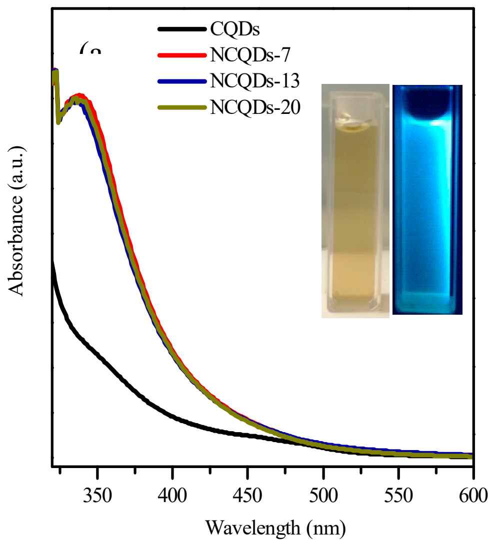


Figure S3. EDX spectra of N-CQDs samples, (a) N-CQD-3, (b) N-CQD-5, (c) N-CQD-7, and (d) N-CQD-20.



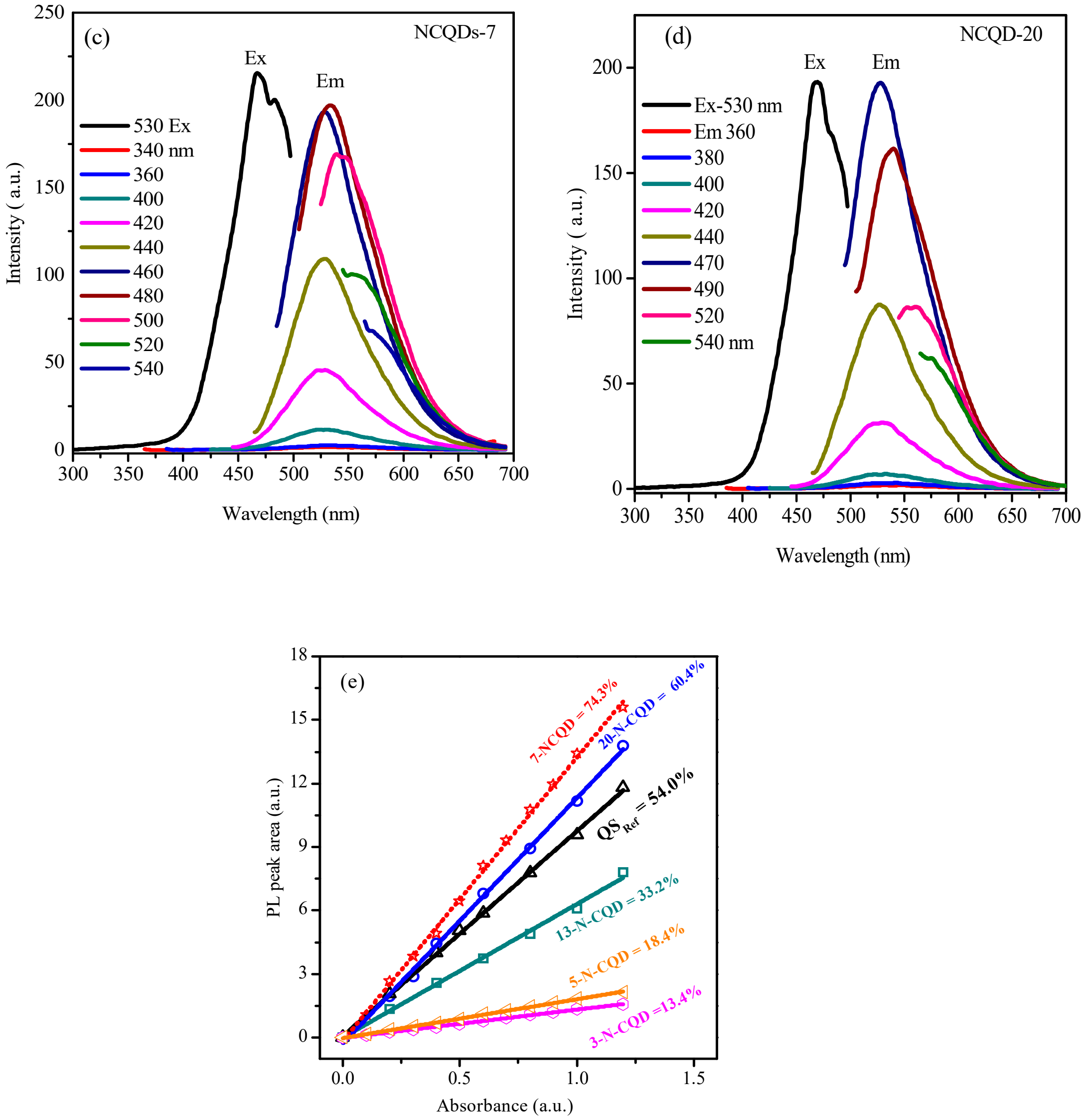


Figure S4. (a) UV-Vis absorption spectra for the CQDs and N-CQDs samples. Inserts show digital photos of aqueous N-CQD-7 (left) and their bright blue PL (right) under UV, (b,c,d) PL spectra for the N-CQD-7, N-CQD-13 and N-CQD-20. The excitation wavelength was increased from 340 to 540 nm in 20 nm increments. (e) External quantum yields for the N-CQDs samples under 360 nm excitation, calibrated against quinine sulfate.

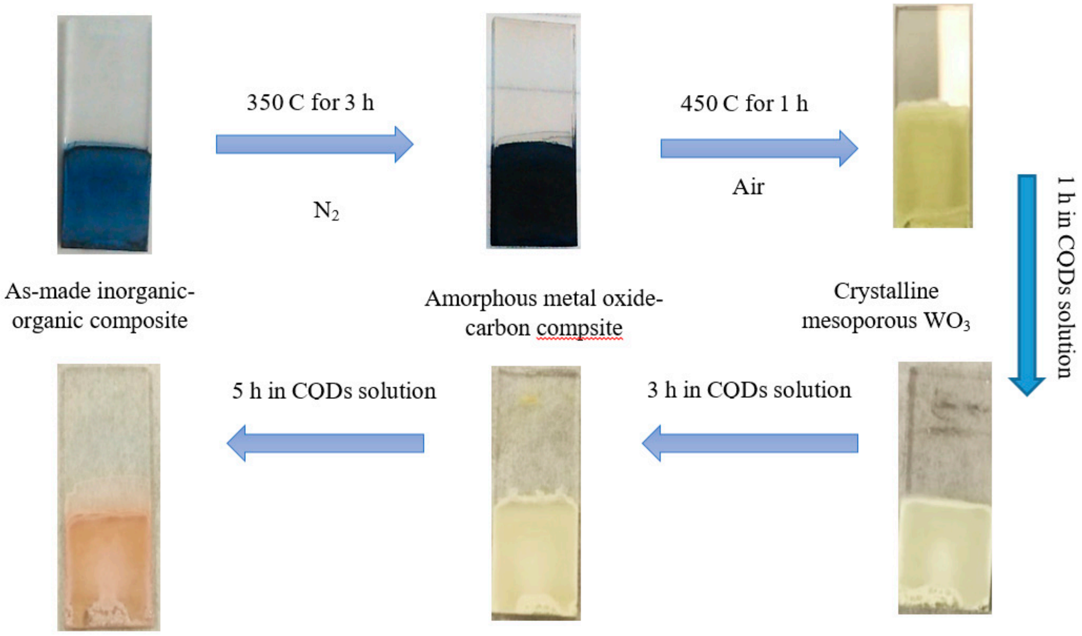


Figure 5. steps for the synthesis of *meso*-WO_3 and modification with CQDs.

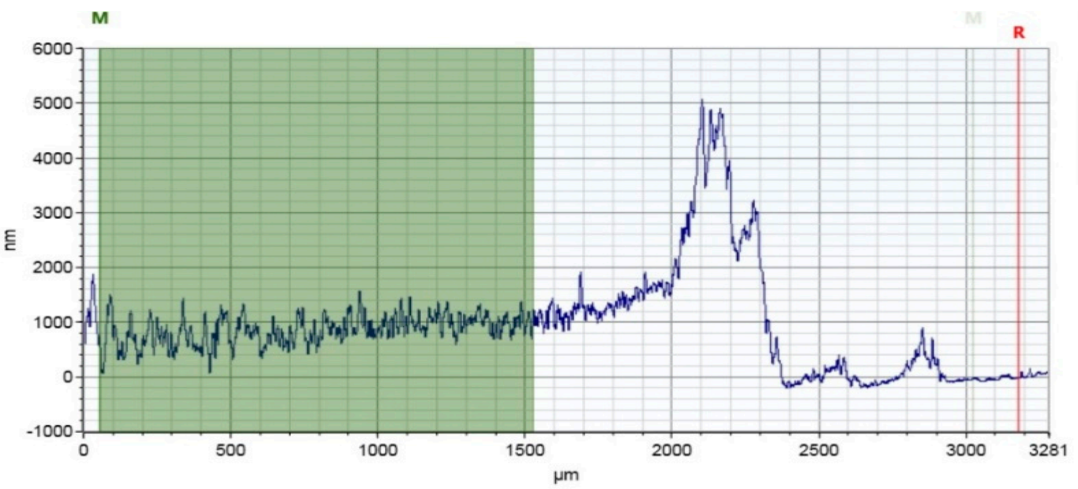


Figure 6. Thickness of of *meso*-WO_3 and modification with CQDs as measured by prophilometer.

Table 1. Comparison the photocurrent density of WO_3 based composite materials.

Photoelectrodes	Synthesis method	BET surface area (m^2/g)	Pore volume cm^3/g	Pore size (nm)	Photocurrent Density	Light Source	Electrolyte	Ref.
NCQDs/*meso*-WO_3	Impregnation/ surfactant self-assembly	105	0.27	5.0	1.45 mA cm^{-2}, 1.23 V vs RHE	AM 1.5G, 100 mW cm^{-2}	0.5 M Na_2SO_4	This Work
NCQDs/*meso*-WO_3 (450 °C)	Impregnation/ surfactant self-assembly	28	0.071	7.5	0.40 mA cm^{-2}, 1.23 V vs RHE	AM 1.5G, 100 mW cm^{-2}	0.5 M Na_2SO_4	This Work
Bulk-WO_3	Impregnation/ no surfactant	18	0.038	--	0.25 mA cm^{-2}, 1.23 V vs	AM 1.5G, 100 mW cm^{-2}	0.5 M Na_2SO_4	This Work

CQDs/WO_3 nanoplates	immersing /hydrothermal	--		--	1.18 mA cm^{-2}, 1.23 V vs RHE	simulated solar light	0.5 M Na_2SO_4	S1
CQDs/WO_3 nanoflakes	Seed-mediated solvothermal	--		--	1.46 mA cm^{-2}, 1.0 V vs. Ag/AgCl	AM 1.5G, 100 mW cm^{-2}	1 M H_2SO_4	S2
NCDs/WO_3 nanoflakes	Seed-mediated hydrothermal	--	--	--	1.42 mA cm^{-2}, 1.0 V vs. SCE	AM 1.5G, 100 mW cm^{-2}	1 M H_2SO_4	S3
CDots/WO_3 nanorods	Reflux/hydrothermal	--	--	--	11.5 µA cm^{-2}	150 W Xe lamp, (780> λ> 420 nm)	0.1 M Na_2SO_4	S4
Z-scheme WO_3/C_3N_4	Electrophoretic deposition	--	--	--	0.82 mA cm^{-2}, 1.23 vs RHE	AM 1.5G, 100 mW cm^{-2}	0.5 M Na_2SO_4	S5
Nanoporous carbon / WO_3	Wet chemistry	--	--	--	~ 8 µA cm^{-2}, 0.6 V vs. Ag/AgCl	blue LED, 371 nm	0.5 M Na_2SO_4	S6
rGO/WO_3	Thermal treatment	31.7	--	--	~1.1 mA cm^{-2}, 1 V vs Ag/AgCl	AM 1.5 G, 100 mW cm^{-2}	0.5 M H_2SO_4	S7
rGO/Nano-plate-WO_3	Wet chemistry / thermal decomposition	175.6	--	--	30 µA cm^{-2}, 0.6V vs. Ag/AgCl	AM 1.5G, 100 mW cm^{-2}	0.1 M Na_2SO_4	S8

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