# Supplementary Information

## Oxygen-rich *g*-$C_3N_4$ Quantum Dot Engineered Graphene Cathode Enabling Highly Selective 2e$^-$ Oxygen Reduction Reaction in Value-added Reaction-assisted Zn-air Battery

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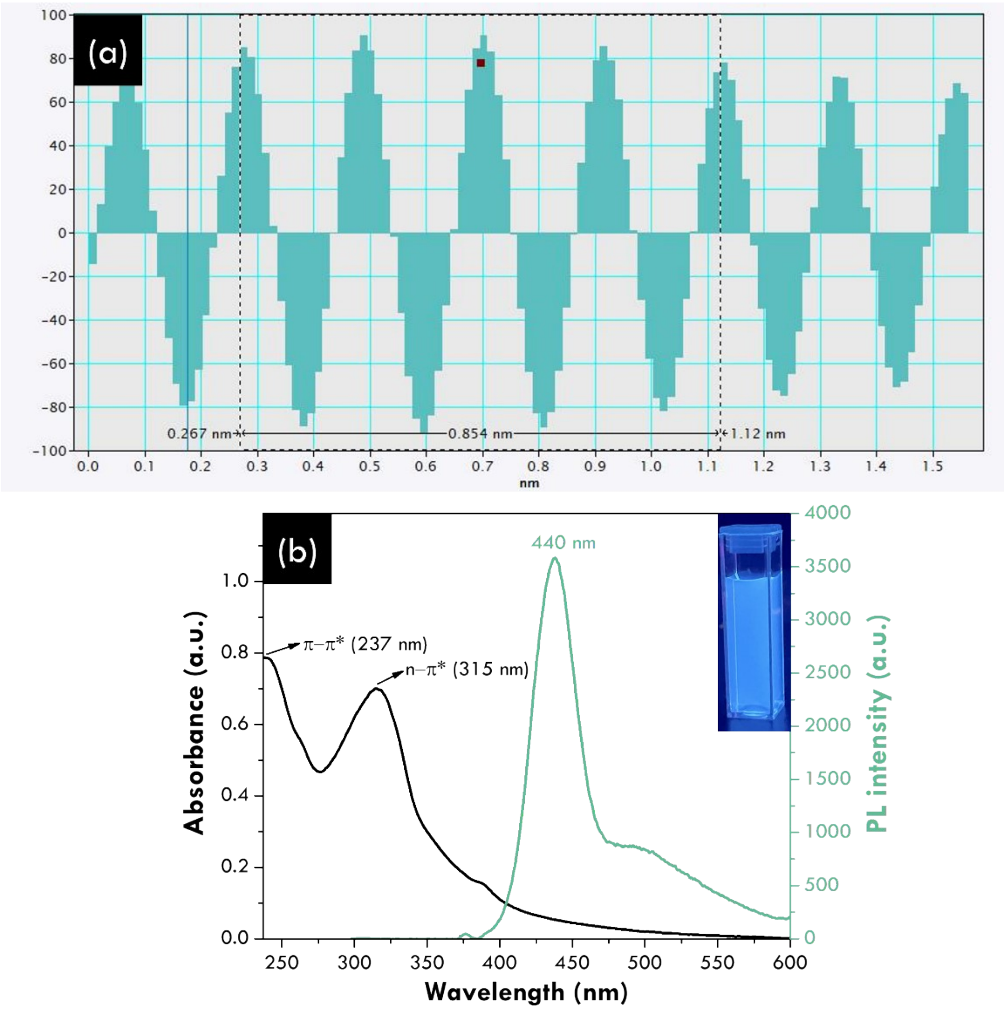


**Figure S1**. (a) The corresponding d-spacing analysis from the TEM image of CNQDs. (b) The UV-Vis absorbance and PL spectra of CNQDs with the inset of CNQDs irradiated with 365 nm light.

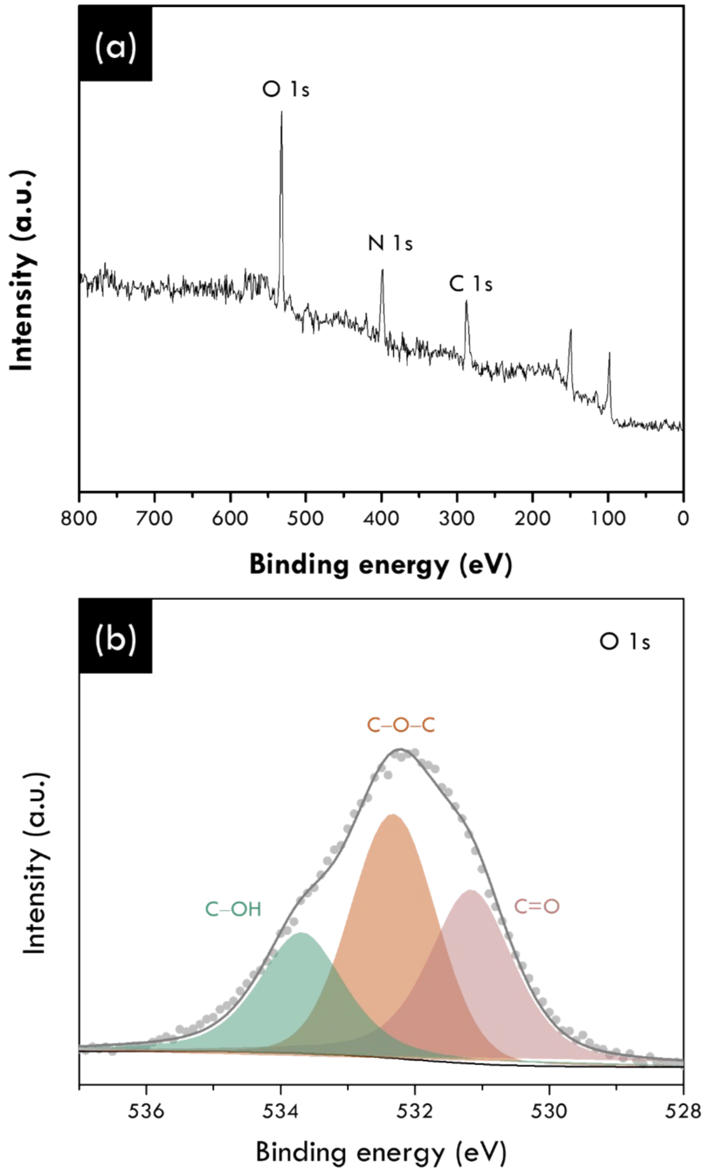


**Figure S2**. The high resolution XPS (a) survey and (b) O 1s spectra of CNQDs.

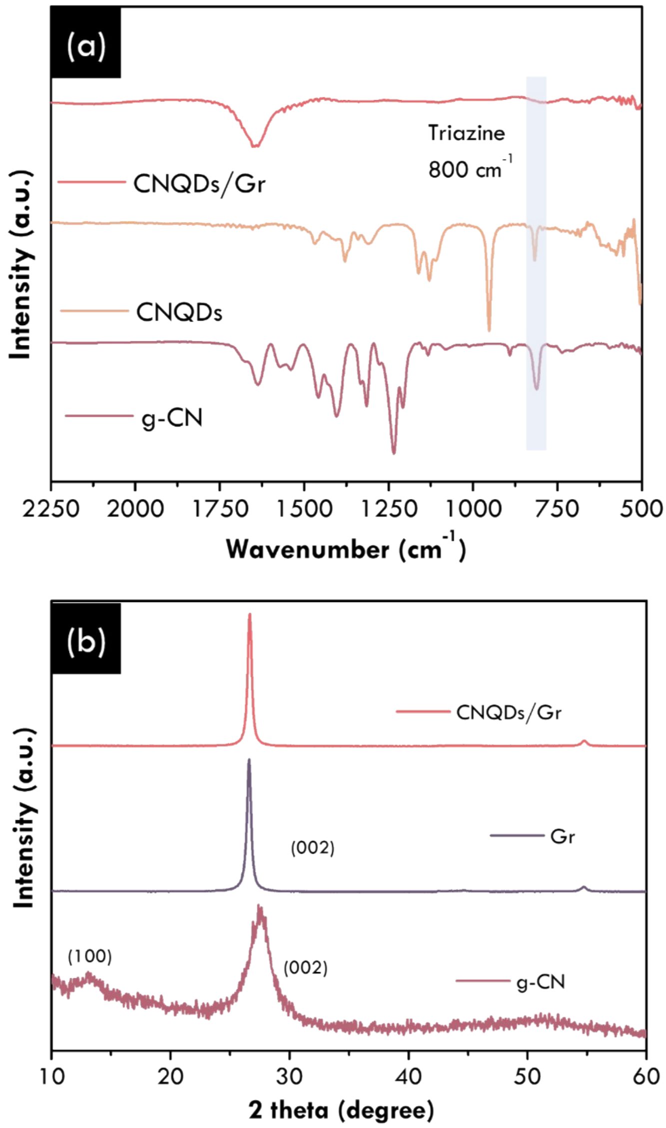


**Figure S3**. (a) FTIR spectra of g-CN, CNQDs, and CNQDs/Gr. (b) XRD patterns of g-CN, Gr, and CNQDs/Gr.

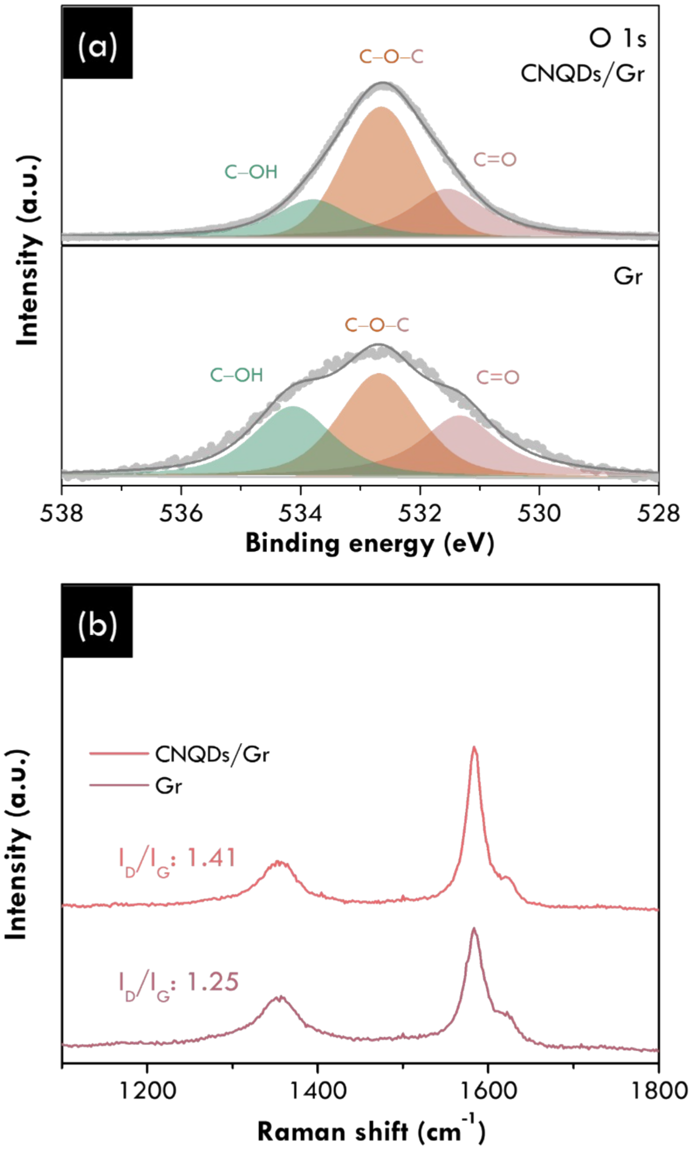


**Figure S4.** (a) High resolution XPS spectra of O 1s for CNQDs/Gr and Gr. (b) Raman spectra of Gr and CNQDs/Gr.

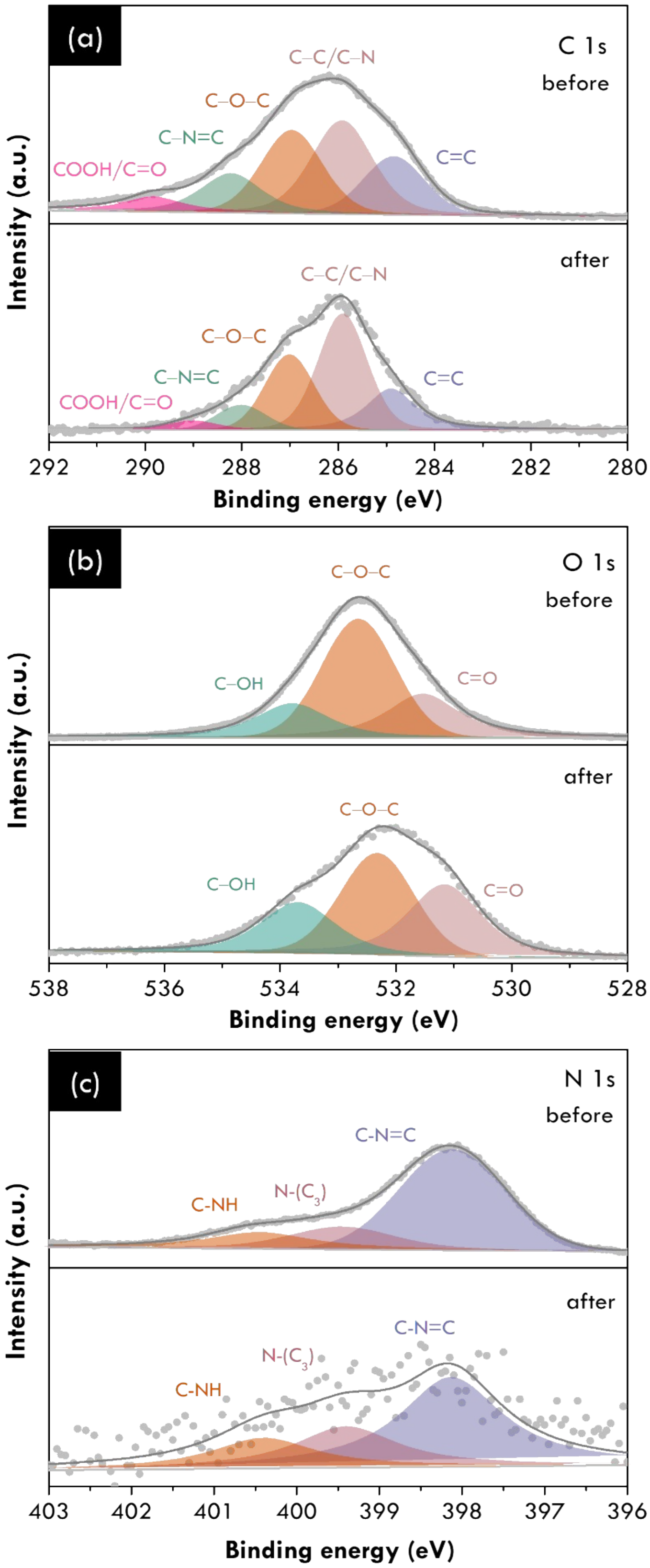


**Figure S5.** High-resolution XPS spectra of (a) C 1s, (b) O 1s, and (c) N 1s for CNQDs/Gr before and after ORR.

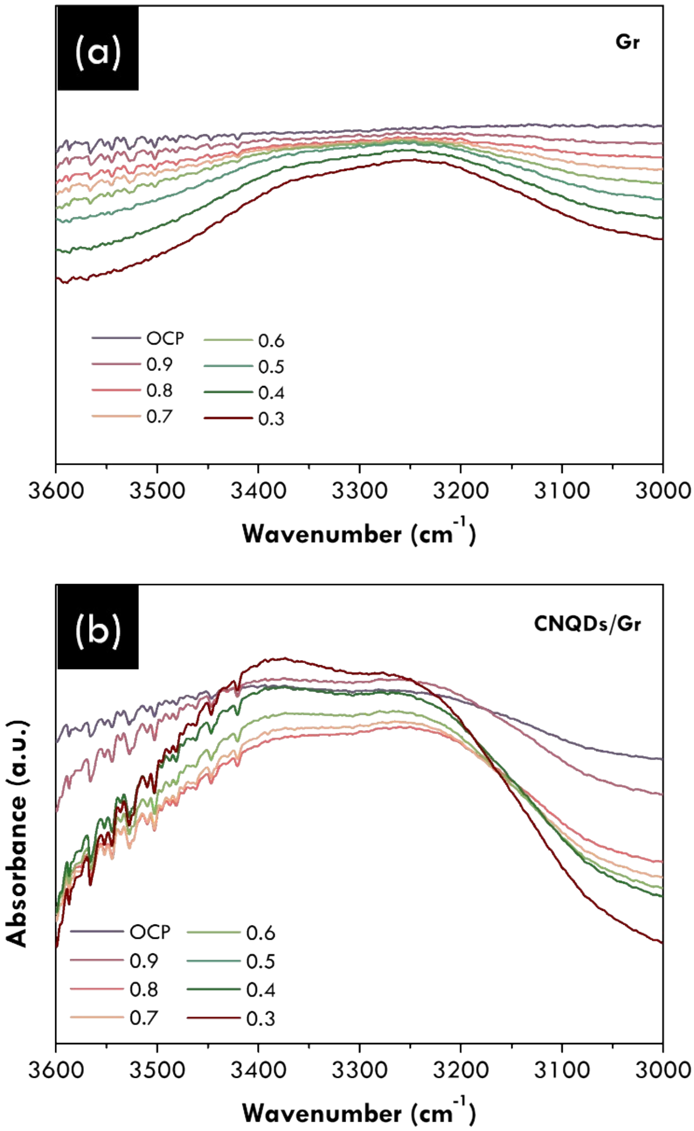


**Figure S6.** In-situ ATR-FTIR spectra of (a) Gr and (b) CNQDs/Gr at the wavenumber of 3000 – 3600 $cm^{-1}$.

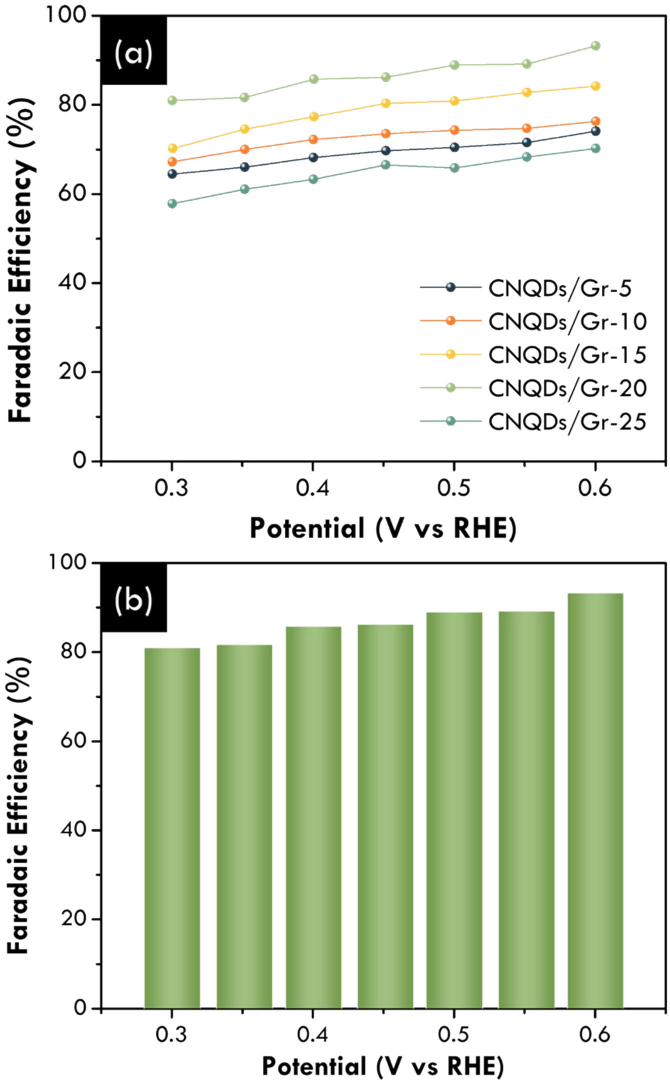


**Figure S7**. (a) Faradaic efficiency of varied concentration of CNQDs on Gr. (b) Faradaic efficiency of CNQDs/Gr-20 on various potential.

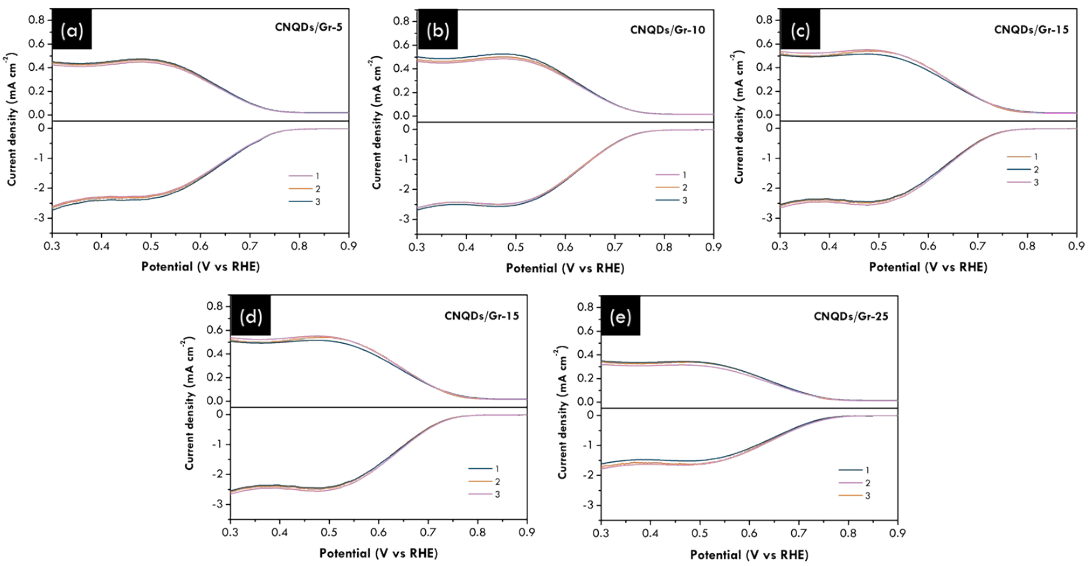


**Figure S8.** (a) The multiple LSV data from each sample of CNQDs/Gr-5, (b) CNQDs/Gr-10, (c) CNQDs/Gr-15, (d) CNQDs/Gr-20, (e) CNQDs/Gr-25.

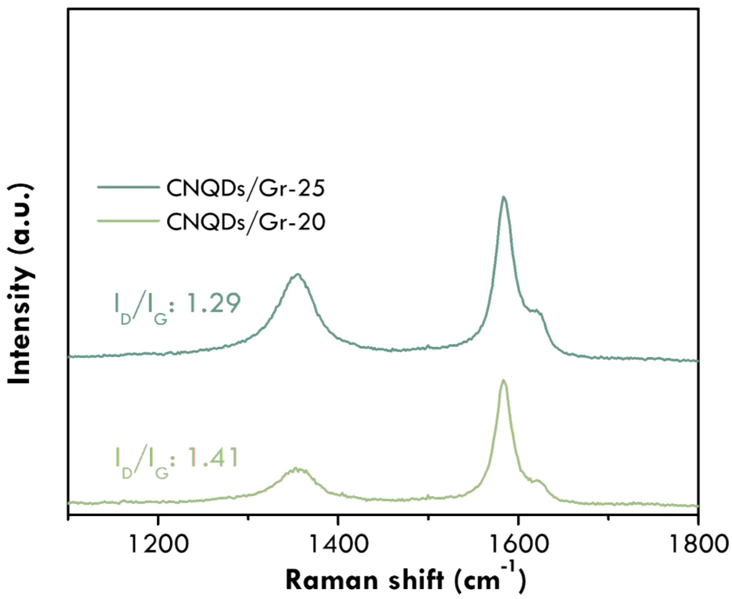


**Figure S9**. Raman spectra of CNQDs/Gr-20 and CNQDs/Gr-25.

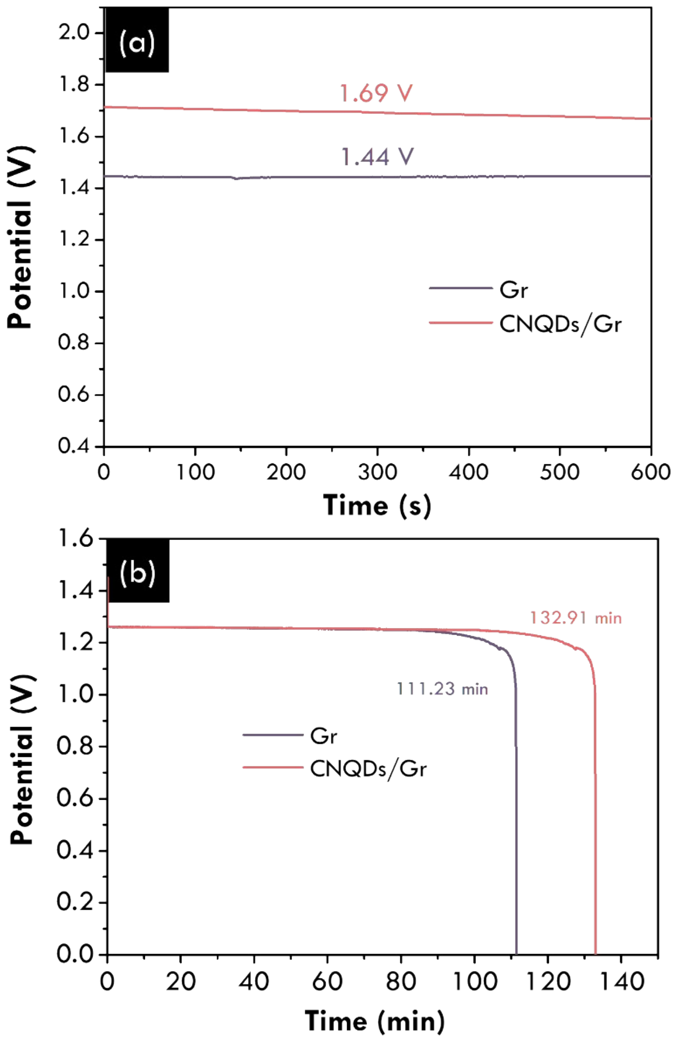


**Figure S10**. (a) Open circuit potential values of Gr and CNQDs/Gr. (b) Time-based specific discharge for Gr and CNQDs/Gr.

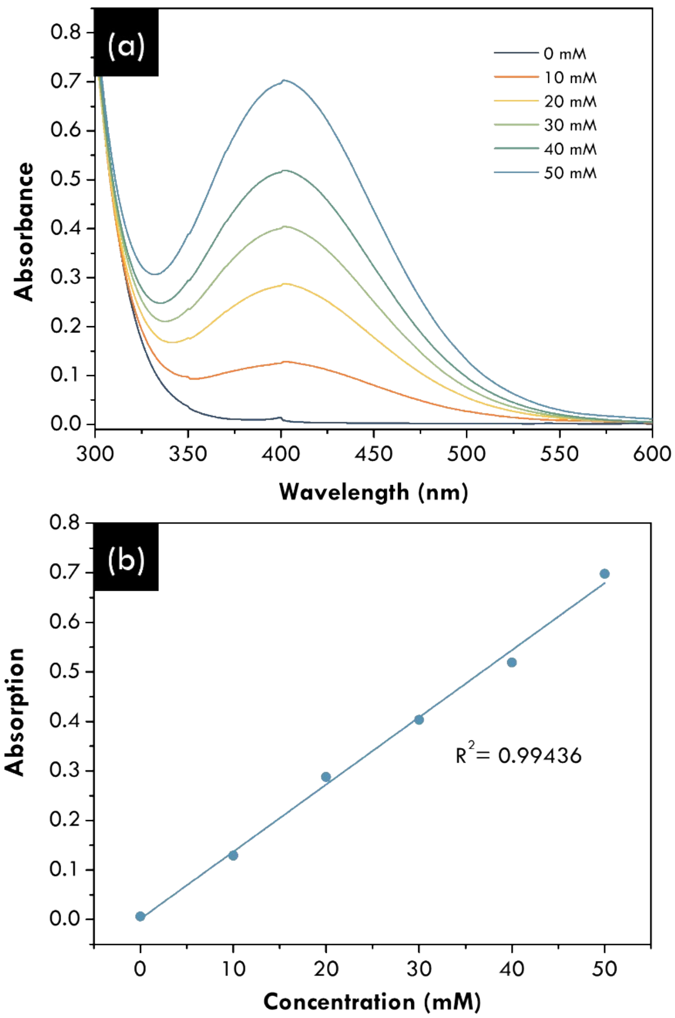


**Figure S11**. (a) The UV absorption spectra of PTO for various concentrations of $H_2O_2$. (b) Corresponding calibration curve of $H_2O_2$ concentrations.

**Table S1.** Comparison of C 1s peak deconvolution area of CNQDs/Gr, Gr, and CNQDs

| Sample | C=C (%) | C-N/ C-C (%) | C-O-C (%) | C-N=C (%) | C=O/ COOH (%) |
|---|---|---|---|---|---|
| CNQDs/Gr | 19.90 | 21.19 | 20.69 | 19.50 | 18.72 |
| Gr | 60.29 | 25.42 | 14.29 | - | - |
| CNQDs | - | 40.14 | 19.93 | 20.40 | 19.53 |

**Table S2.** The comparison of $H_2O_2$ yield in alkaline solution (pH 13).

| Catalyst | Loading (mg cm$^{-2}$) | $H_2O_2$ (%) | FE (%) | Rate (mmol $g_{cat}^{-1}$ $h^{-1}$) | Source |
|---|---|---|---|---|---|
| $Ni_{20}Py$ | 1.00 | 97.0 | 96.0 | 1574 | 1 |
| Co-N-C | 0.10 | 80.0 | 59.0 | 4330 | 2 |
| G-COF-T | 0.10 | 75.0 | 69.8 | 1287 | 3 |
| HNCS | 0.50 | 91.9 | 85.1 | 619 | 4 |
| NCMK3IL50_800T | 0.05 | - | 70.0 | 561 | 5 |
| a-CB | 2.00 | >95.0 | 90.4 | 1302 | 6 |
| CNQDs/Gr | 1.00 | 96.5 | 93.2 | 3992 | This work |

**References**


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