

Communication

Nitrogen-Doped Graphene Quantum Dots with Oxygen-rich Functional Groups

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The electrochemical process for the formation of N GQDs is shown in Figures S1 and S₂. Just like the oxidation of other carbon materials by an oxidant

ods. Comparing with GQDs however N GQDs exhibit a broader D band suggesting that the intercalation of N atoms into the conjugated carbon backbone has led to somewhat disordered structures.

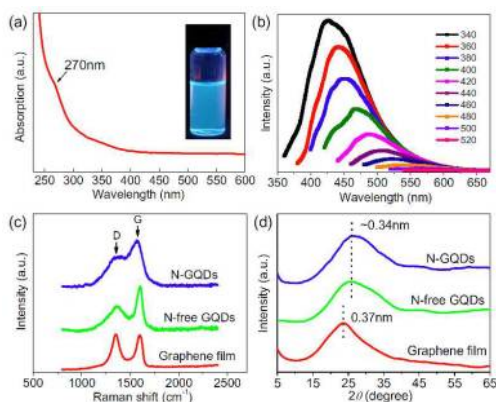


Figure 3. a and b UV vis absorption and photoluminescence PL spectra of N GQDs in water respectively. c Raman spectra and d XRD patterns of the original graphene film the N free and N GQDs. Inset in a is a photo of the N GQD solution in water under 270 nm UV irradiation.

Figure d shows typical XRD profiles for the original graphene film and the as prepared N free and N GQDs. Just like their N free counterparts the N GQDs show a broader diffraction peak at around 2° which is substantially higher than that of the graphene film $ca. 2^\circ$. The more compact interlayer spacing $ca. 0.4$ nm probed by XRD for N GQDs than the original graphene film $ca. 0.37$ nm is consistent with the TEM observation Figure S4. The reduced interlayer spacing in N GQDs could be attributed to the effective $\pi-\pi$ stacking of tiny graphenes with few structure defects Figure S4. On the other hand the possible formation of hydrogen bonding between the O containing functional groups surrounding the edges of the graphene layers in N GQDs Figures S4 and S5 may further facilitate the compact stacking of graphene layers Figure S4. It is also worth to note that N GQDs thus prepared do not show any diffractions in the region of $ca. 10^\circ$ 2θ characteristic of graphene oxides¹ evidently indicating that the N GQDs are different from graphene oxide though both contain oxygen enriched functional groups Figure 2.

N doped carbon nanomaterials such as N CNTs and N graphene⁴ have been demonstrated to hold promise as metal free electrocatalysts in replacing the commercially available Pt based catalyst for ORR. Apart from their unique luminescent properties N GQDs are also expected to possess the electrocatalytic activities for ORR. To avoid any possible effect of the glassy carbon GC base electrode Figure S9 we used a large area and electrically conductive graphene assembly to support the N GQD as ORR catalysts. The graphene supported N GQDs N GQDs/graphene were prepared by hydrothermal treatment of the suspension of well dispersed graphene oxides with N GQDs Figure S10. This mild process ensured the formation of N GQD/graphene assemblies without acutely changing the intrinsically chemical nature of N GQDs Figures S11–S12. The N GQD/graphene film Figure S1 thus formed was demonstrated to exhibit a good conductivity of $ca. 0.5$ S/cm and superior electrocatalytic ability for ORR see below.

Figures 4a and b depict CVs for O_2 reduction on the N GQD/graphene in comparison with a commercial Pt/C catalyst

A₂:Goaw 199 d Gahw 21 TC90-60 Tur S 20 L
C₂H₂:Zhou X B TuTCDo cduhu z q h aka 199 m 1 001 ; 1

Table of Content Graphic



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
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28
29
30
31
32
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34
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36
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47
48
49
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57
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59
60