Communication

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

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J. Am. Chem. Soc., **Just Accepted Manuscript** • DOI: 10.1021/ja206030c • Publication Date (Web): 02 Dec 2011

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

Yan Li,[†,#] Yang Zhao,[†,#] Huhu Cheng,[†] Yue Hu,[†] Gaoquan Shi,[‡] Liming Dai,[§] and Liangti Qu[*,†]

[†]Key Laboratory of Cluster Science, Ministry of Education of China, School of Chemistry, Beijing Institute of Technology, Beijing 100081, P. R. China
[‡]Department of Chemistry, Tsinghua University, Beijing 100084, P. R. China
[§]Department of Macromolecular Science and Engineering, Case School of Engineering, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, Ohio 44106, United States
[*]Corresponding author: lqu@bit.edu.cn. [#]

The electrochemical process for the formation of N GQDs is shown in Figures S1 and S ⊢ 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 con jugated carbon backbone has led to somewhat disordered struc tures.

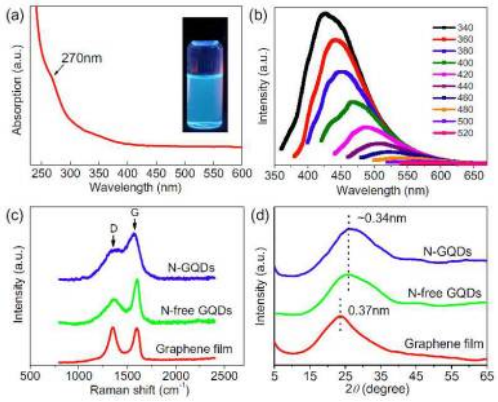

Figure 3. a and b UV vis absorption and photoluminescence PL spectra of N GQDs in water respectively. c Raman spectra and d XRD patterns of the original graphene film the N free and N GQDs. Inset in a is a photo of the N GQD solution in water under nm UV irradiation.

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 ° which is substantially higher than that of the gra phene film *ca.* . ° . The more compact interlayer spacing *ca.* 0. nm probed by XRD for N GQDs than the original graphene film *ca.* 0. nm is consistent with the TEM observation Figure S . The reduced interlayer spacing in N GQDs could be attrib uted to the effective π π stacking of tiny graphenes with few struc ture defects Figure d . 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 d S and S may further facilitate the compact stacking of gra phene layers Figure S . It is also worth to note that N GQDs thus prepared do not show any diffractions in the region of *ca.* 10° θ characteristic of graphene oxides [1] evidently indicating that the N GQDs are different from graphene oxide though both contain oxygen enriched functional groups Figure .

N doped carbon nanomaterials such as N CNTs and N graphene[4] 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 activi ties for ORR. To avoid any possible effect of the glassy carbon GC base electrode Figure S we used a large area and electri cally 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 intrinsi cally chemical nature of N GQDs Figures S11 S1 . The N GQD graphene film Figure S1 thus formed was demonstrated to exhibit a good conductivity of *ca.* 0 S cm and superior elec trocatalytic ability for ORR see below .

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

In summary we have developed a simple yet effective electrochemical strategy to generate N doped GQDs with O rich functional groups which show unique optoelectronic features distinctive from their N free counterparts Supported by graphene sheets N GQDs were demonstrated to possess superior electrocatalytic ability Apart from the use of N GQDs as metal free catalyst for ORR their unique luminescent properties indicate potentials for bioimaging and light emitting diodes among many other potential applications

ACKNOWLEDGMENTS. This work was supported by NSFC 10 00 11 01 National Basic Research Program of China 011CB01 000 the 111 Project B0 01 and NCET 10 0 LD thanks NSF CMMI 1000 and AFOSR FA 10 1 0 1 for partial support

Supporting Information The experimental details for preparation of N GQDs N GQD graphenes electrode fabrication related characterization and supplementary results and discussion This material is available free of charge via the Internet at http pubs acs org

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