Electronic Supplementary Material (ESI) for RSC Advances.

A reformative oxidation strategy using high concentration nitric acid for enhancing emission performance of graphene quantum dots

Taili Shao,[a,b] Guodong Wang,[b] Xuting An,[a] Shujuan Zhuo,[a] Yunsheng Xia*[a] and Changqing Zhu*[a]

[a]*Anhui Key Laboratory of Chemo-Biosensing, College of Chemistry and Materials Science, Anhui Normal University, Wuhu 241000, People's Republic of China*

[b]*School of Pharmacy, Wannan Medical College ,Wuhu 241002, People's Republic of China*

xiayuns@mail.ahnu.edu.cn; zhucq@mail.ahnu.edu.cn

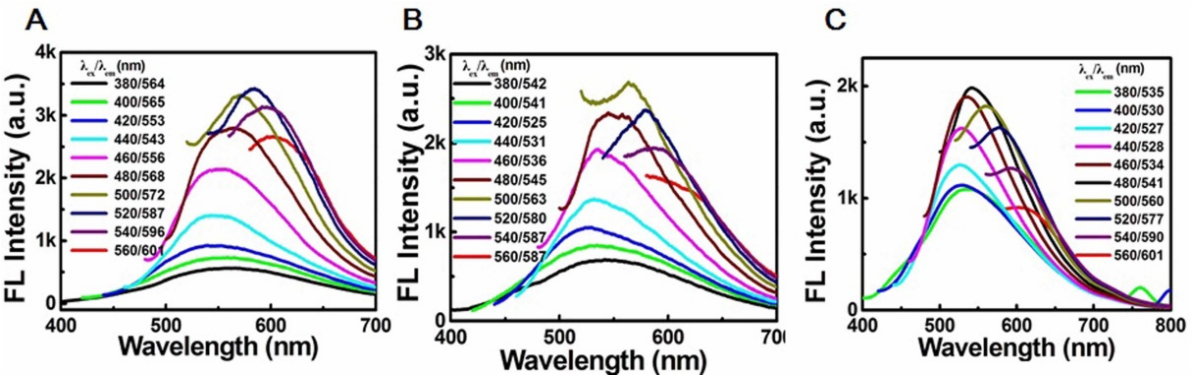

Fig. S1 The fluorescence spectra of the GQDs synthesized by different concentration of nitric acid (reaction time is 3 h) at the excitation wavelengths from 380 nm to 560 nm in 20 increments. (A) 12 M, (B) 10 M, (C) 8 M, respectively.

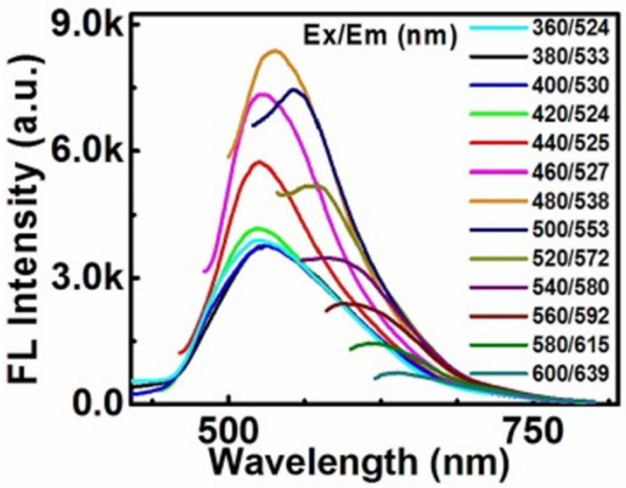

Fig. S2 The fluorescence spectra of the GQDs derived from alcohol lamp soot by concentrated nitric acid oxidation.

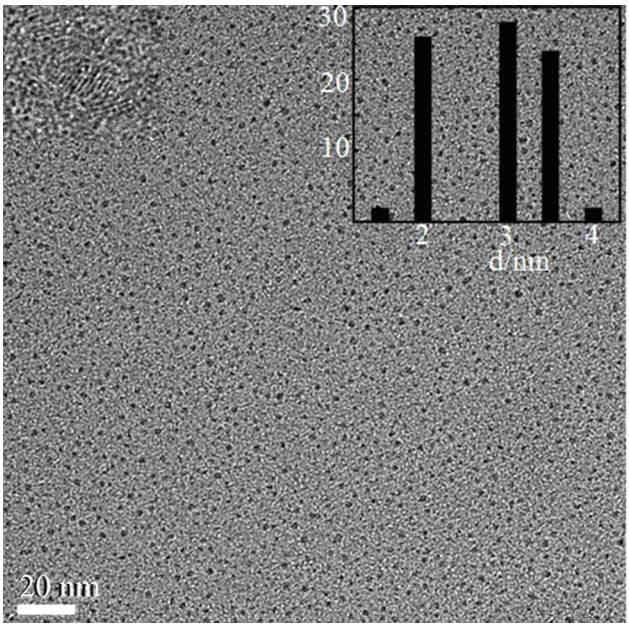

Fig. S3 The TEM image of the GQDs derived from alcohol lamp soot by concentrated nitric acid oxidation. Insert: HRTEM (left) and the size distribution (right).

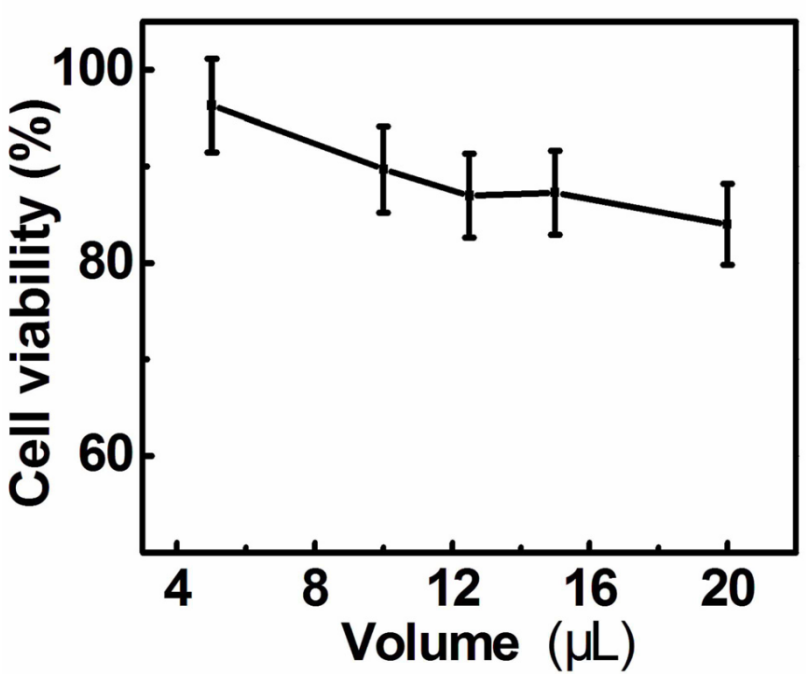

Fig. S4 Cell viability by MTT assay. The concentration of the as-prepared GQDs is 0.5 mg mL^{-1}.

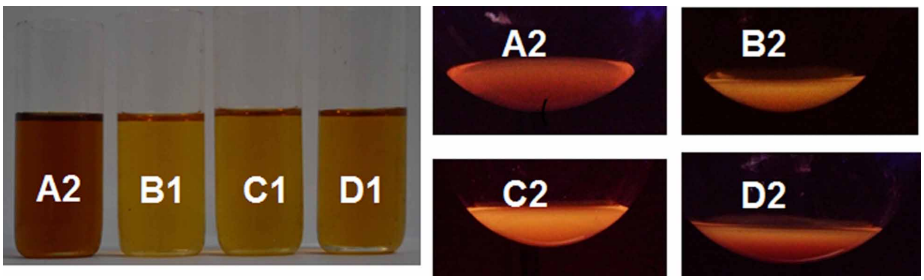

Fig. S5 The photographs of 0.25 mg mL^{-1} of the as-prepared GQDs under room light and UV light (365 nm) in *N*, *N*-dimethylformamide (A1, A2), water (B1, B2), alcohol (C1, C2), ethyl acetate (D1, D2), respectively.

Table S1 The wavelengths of the maximum emission and QYs of some obtained GQDs.

Wavelengths of the maximum emission	QYs[a]	Methods
520 nm	---------	Carbon dots derived from tire soot by HNO_3 oxidation.[1]
450 nm	---------	Graphene nanoparticles (GNPs) from carbon fibers.[2]
~ 450 nm	4-10%	Laser ablation of graphite powder.[3]
515 nm	11.4%	Solvothermal route from graphene oxide.[4]
435, 510 nm	2.4, 1.1%	Hydrothermal treatment of glucose.[5]
540 nm	14%	Electrochemical method from graphite rods.[6]
441 nm	26%	One-step by hydrothermal treatment of orange juice.[7]
448 nm	11%	A hydrothermal method using bovine serum albumin.[8]
514 nm	22%	Synthesized by using CCl_4 and $NaNH_2$.[9]
450 nm	7.0-15.3%	Microwave assisted pyrolysis of glycerol and PEI25k.[10]
450 nm	12.02%	Microwave assisted pyrolysis of glycerol.[11]
440 nm	13%	Microwave assisted pyrolysis of soya bean grounds.[12]
600 nm	18%	GQDs derived from activated carbon by HNO_3 oxidation.[b]

[a]quantum yields; [b]reported in this paper; ------ not reported in corresponding papers

Table S2 Comparison of the size and composition of the reported crude GQDs with as-prepared carbon dots using chemical oxidation method

Start materials	Size	Element analysis (C:H:N:O) wt%	QYs
Carbon fibers[1]	3-6 nm	------	------
Tire soot [2]	8-15 nm	------	-------
Arc-discharged soot [13]	1×18 nm	53.93:2.56:1.20:40.33	1.6%
Activated carbon[14]	~ 4.5 nm	68.16:5.42:1.01:25.41	~ 1.5%
Resols[15]	1.5-2.5 nm	90.32:1.36:0:8.34	------
Carbohydrates [16]	2-6 nm	68.16:3.99:0:27.82	1%
Candle Soot[17]	2-6 nm	96:0:0:4	3%
Coal activated carbon[18]	3-4 nm	50.01:1.01:1.67:47.31	------
Activated carbon [b]	3.3-12 nm	57.13:4.10:4.31:32.12	18%

Table S3 The fluorescence wavelengths and QYs of GQDs obtained from different concentration of nitric acid.

The concentration of HNO_3 (M)	14.6	12	10	8
Fluorescence wavelength (nm)	600	587	563	541
QYs (%)	18	8.7	6.1	5

References

[1] H. Y. Ko, Y. W. Chang, G. Paramasivam, M. S. Cho, S. Jeong, S. Kim, *Chem. Commun*., 2013, **49**, 10290.

[2] M. Nurunnabi, Z. Khatun, G. R. Reeck, D. Y. Lee, Y. K. Lee, *Chem. Commun*., 2013, **49**, 5079.

[3] Y. P. Sun, B. Zhou, Y. Lin, W. Wang, K. A. S. Fernando, P. Pathak, M. J. Meziani, B. A. Harruff, X. Wang, H. F. Wang, P. G. Luo, H. Yang, M. E. Kose, B. Chen, L. M. Veca, S. Y. Xie, *J. Am. Chem. Soc*., 2006, **128**, 7756.

[4] S. J. Zhu, J. H. Zhang, C. Y. Qiao, S. J. Tang, Y. F. Li, W. J. Yuan, B. Li, L. Tian, F. Liu, R. Hu, *Chem. Commun*., 2011, **47**, 6858.

[5] Z. C. Yang, M. Wang, A. M. Yong, S. Y. Wong, X. H. Zhang, H. Tan, A. Y. Chang, X. Li, J. Wang, *Chem. Commun*., 2011, **47**, 11615.

[6] M. Zhang, L. L. Bai, W. H. Shang, W. J. Xie, H. Ma, Y. Y. Fu, D. C. Fang, H. Sun, L. Z. Fan, M. Han, *J. Mater. Chem*., 2012, **22**, 7461.

[7] S. Sahu, B. Behera, T. K. Maiti, S. Mohapatra, *Chem. Commun*., 2012, **48**, 8835.

[8] Z. Zhang, J. H. Hao, J. Zhang, B. L. Zhang, J. L. Tang, *RSC Adv*., 2012, **2**, 8599.

[9] Y. Q. Zhang, D. K. Ma, Y. Zhuang, X. Zhang, W. Chen, L. L. Hong, Q. X. Yan, K. Yu, S. M. Huang, *J. Mater. Chem*., 2012, **22**, 16714.

[10] C. J. Liu, P. Zhang, X. Y. Zhai, F. Tian, W. C. Li, J. H. Yang, Y. Liu, H. B. Wang, W. Wang, W. G. Liu, *Biomaterials*, 2012, **33**, 3604.

[11] C. J. Liu, P. Zhang, F. Tian, W. C. Li, F. Li, W. G. Liu, *J. Mater. Chem*., 2011, **21**, 13163.

[12] W. B. Li, Z. Yue, C. Wang, W. Zhang, G. H. Liu, *RSC Adv*., 2013, **3**, 20662.

[13] X. Y. Xu, R. Ray, Y. L. Gu, H. J. Ploehn, L. Gearheart, K. Raker, W. A. Scrivens, *J. Am. Chem. Soc*., 2004, **126**, 12736.

[14] Z. A. Qiao, Y. F. Wang, Y. Gao, H. W. Li, T. Y. Dai, Y. L. Liu, Q. S. Huo, *Chem. Commun*., 2010, **46**, 8812.

[15] R. L. Liu, D. Q. Wu, S. H. Liu, K. Koynov, W. Knoll, Q. Li, *Angew. Chem. Int. Ed*., 2009, **48**, 4598.

[16] H. Peng, J. Travas-Sejdic, *Chem. Mater*., 2009, **21**, 5563.

[17] S. C. Ray, A. Saha, N. R. Jana, R. Sarkar, *J. Phys. Chem. C*, 2009, **113**, 18546.

[18] Y. Q. Dong, N. N. Zhou, X. M. Lin, J. P. Lin, Y. W. Chi, G. N. Chen, *Chem. Mater*., 2010, **22**, 5895.