Graphene Quantum Dots: An Eco-Friendly Preparation

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Abstract

The application of the Principles of the Green Chemistry[1] to nanotechnology is a permanent claim.[2] Nowadays, efforts are focused on the assessment of environmental and safety risks associated with the materials themselves, rather than the risks related to their respective synthesis and/or modification. Synthetic routes are not optimized for satisfying green nanoscience objectives such as energy or waste minimization and this fact is transferred to industrial processes. Mechanochemistry provides shorter reaction times, lower energy consumption and other green aspects related to solvent-free conditions, and has become a useful tool for green and sustainable chemistry.[3]

A lot of methods for prepare GQDs have been reported, but none of them has the appropriated requirements for industrial scale-up. We report a cheap, easy and eco-friendly means to obtain graphene quantum dots (GQDs): ball-milling for the fragmentation of graphite in the presence of sodium percarbonate as solid oxidant. This approach is related to the mechanochemical methodology reported by us for the preparation of few-layered graphene from graphite[4] and carbon fibers.[5] In contrast to the conventional techniques used for the synthesis of graphene, and now for graphene quantum dots, the ball-milling process avoids the use of strong minerals acids, high temperatures and high vacuum chambers, while the solvents, if used, can be recovered and recycled. In addition, the protocol is quite simple, making it possible to set up the experiment in a short time.

As it is known, photoluminescence (PL) is the most valued property of quantum dots and the wavelength of emission in deeply related to the size of the QD as a consequence of the quantum confinement of the excitons.[6] The emission wavelength of the obtained GQDs is quasi-independent of the excitation wavelength. This is indicative of a high level of homogeneity in size and/or Csp2 domains. [Figure 1] In addition large Stokes displacement, 125 nm (λex=315; λem=430), are observed.

Raman spectra show a low level of defect (I_D/I_G <0.6) [Figure 2].

References

[1] P.T. Anastas, J. Warner, Green Chemistry: Theory and Practice; Oxford University Press: Oxford, U.K., 1998.

[2] L. M. Gilbertson, J. B. Zimmerman, D. L. Plata, J. E. Hutchison, P.T. Anastas, Chem. Soc. Rev. 2015, doi: c4cs0045k.

[3] a) L. Takacs, Chem. Soc. Rev. **2013**, *42*, 7649-7659. b) C. F. Burmeister, A. Kwade, Chem. Soc. Rev. **2013**, *42*, 7660-7667. c) G.–W. Wang, Chem. Soc. Rev. **2013**, *42*, 7668-7700.

[4] V. León; M. Quintana; M. A. Herrero; J. L. G. Fierro; A. de la Hoz; M. Prato; E. Vázquez, Chem. Commun., 2011, 47, 10936-10938.

[5] A. E. del Río-Castillo; C. Merino; E. Díez-Barra; E. Vázquez, *Nano Res.,* **2014**, *7*, 963-972

[6] a) L. E. Brus, *Appl. Phys.,* **1991**, *53*, 465-474. b) A. L. Efros, M. Rosen, *Ann. Rev. Mater. Sci.*, **2000**, *30*, 475-521.

Figures

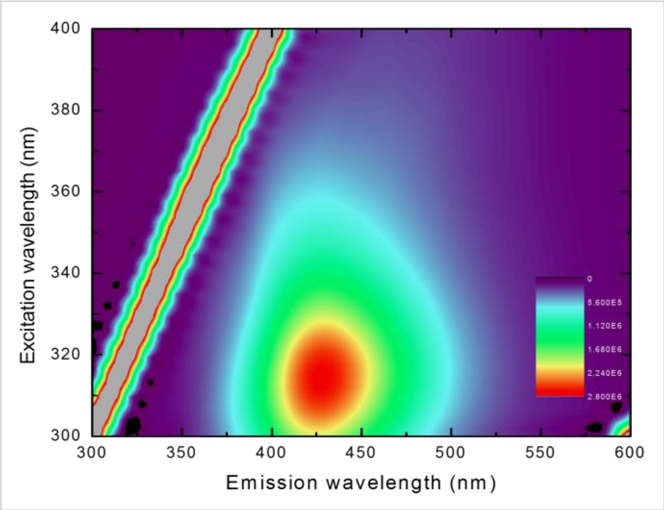

Figure 1: PL spectra (water; [6 mg/mL]

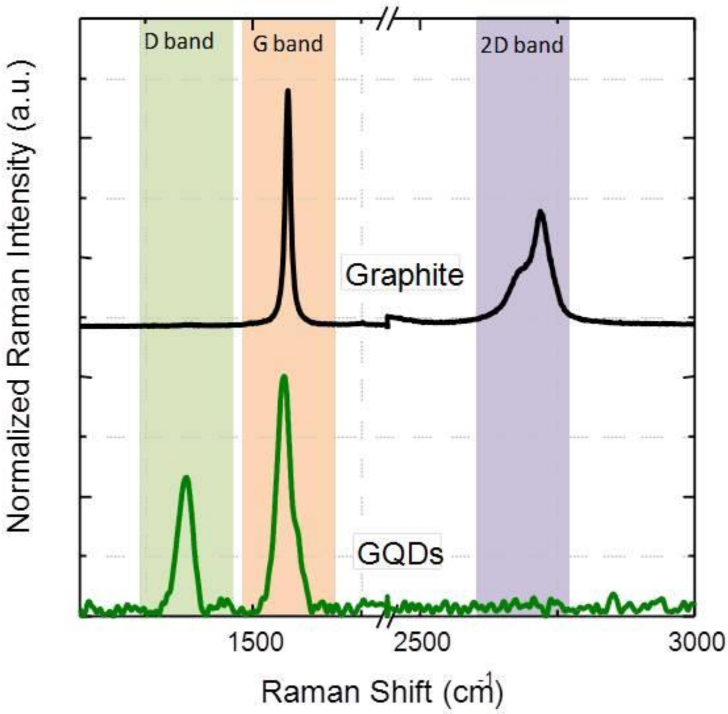

Figure 2: Graphite and GQDs RAMAN spectra