Kumud Malika Tripathi, Tuan Sang Tran, Tran Thanh Tung, Dusan Losic and TaeYoung Kim
Water soluble fluorescent carbon nanodots from biosource for cells imaging
Journal of Nanomaterials, 2017; 2017:7029731-1-7029731-10

Originally published at:
http://doi.org/10.1155/2017/7029731

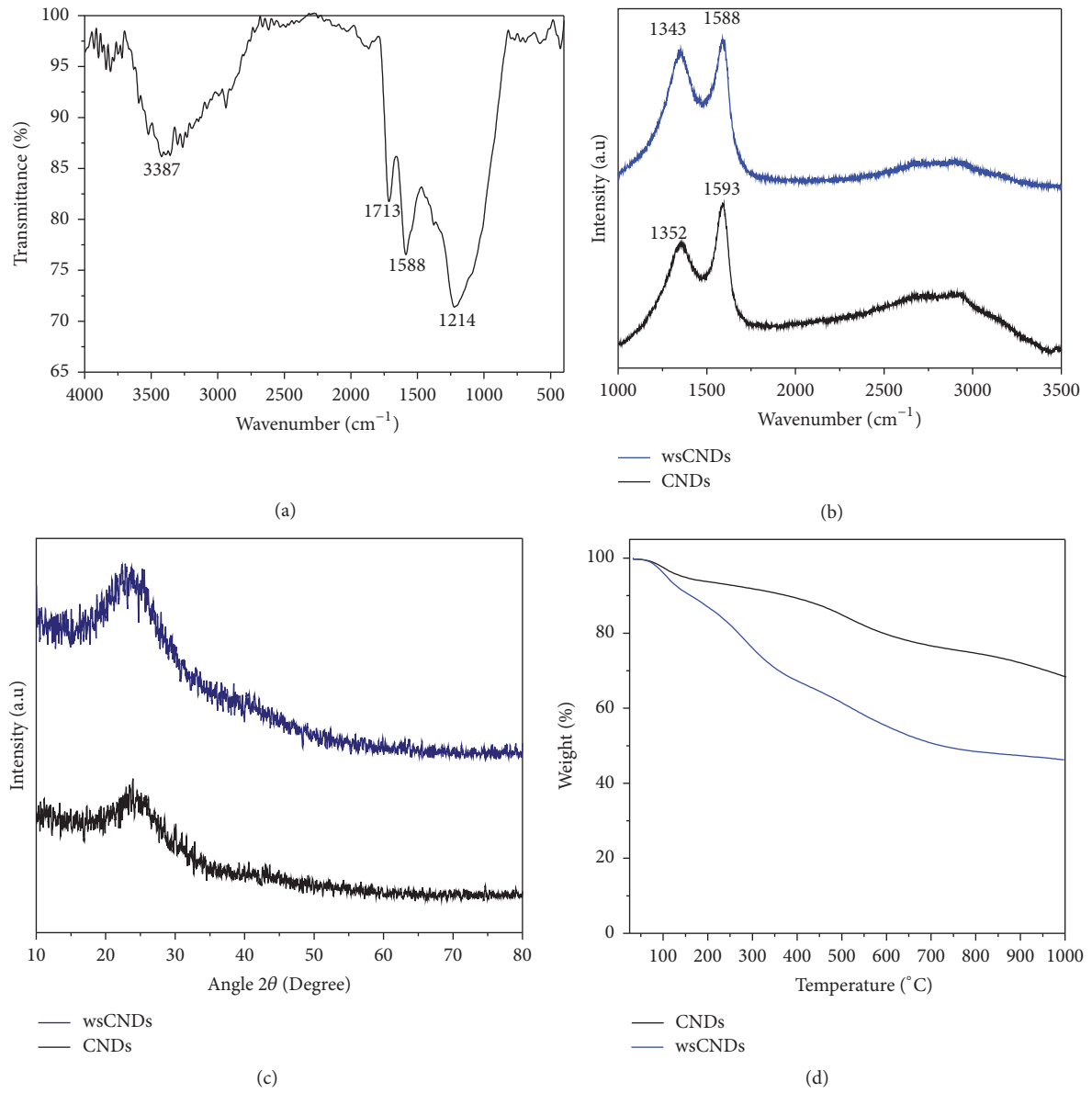

Figure 3: (a) FTIR spectrum of wsCNDs. (b) Raman and (c) XRD spectra of wsCNDs (blue line) and CNDs (black line); (d) thermal gravimetric analysis (TGA) of CNDs (black line) and wsCNDs (blue line).

amorphous carbon, as resulting from partial carbonization of precursor, since there is no sign of background absorbance in the visible region [35]. Aqueous solution of wsCNDs after several weeks of storage at room temperature did not result in any visible aggregation, demonstrating the excellent stability of wsCNDs in solution. A detailed PL study with different excitation wavelengths (λ_{ex}) ranging from 340 to 620 nm was analyzed to explore the optical properties of wsCNDs. The emission spectrum of wsCNDs is excitation dependent as shown in Figure 4(b) and is characterized as a generic feature of nanoparticles possessing carbogenic core [38]. When excitation wavelength changes from 340 to 620 nm on a continuous increase of 20 nm, emission wavelength red-shifted. The PL emission of wsCNDs ranges throughout the visible region of spectrum covers 461–658 nm with maximum intensity at 461 nm centered peak at 340 nm excitation wavelength. The relationship between excitation wavelength and emission wavelength is shown in Figure 4(c). The excitation spectrum at 460 nm emission wavelength exhibited two bands at 332 and 393 nm (Figure 4(d)) which matches with core and surface absorption, respectively, and indicates the presence of various types of light emitting centers [9, 35]. The fluorescence microscopic imaging reveals the highly florescence nature of wsCNDs under different band pass filters as shown in Figures 4(e) and 4(f). wsCNDs exhibited strong green and red emissions in the visible region at 448 and 561 nm band pass filters.

The origin of PL emissions in CNDs still remains a big mystery and is highly controversial with different explanations due to various synthetic approaches and numerous

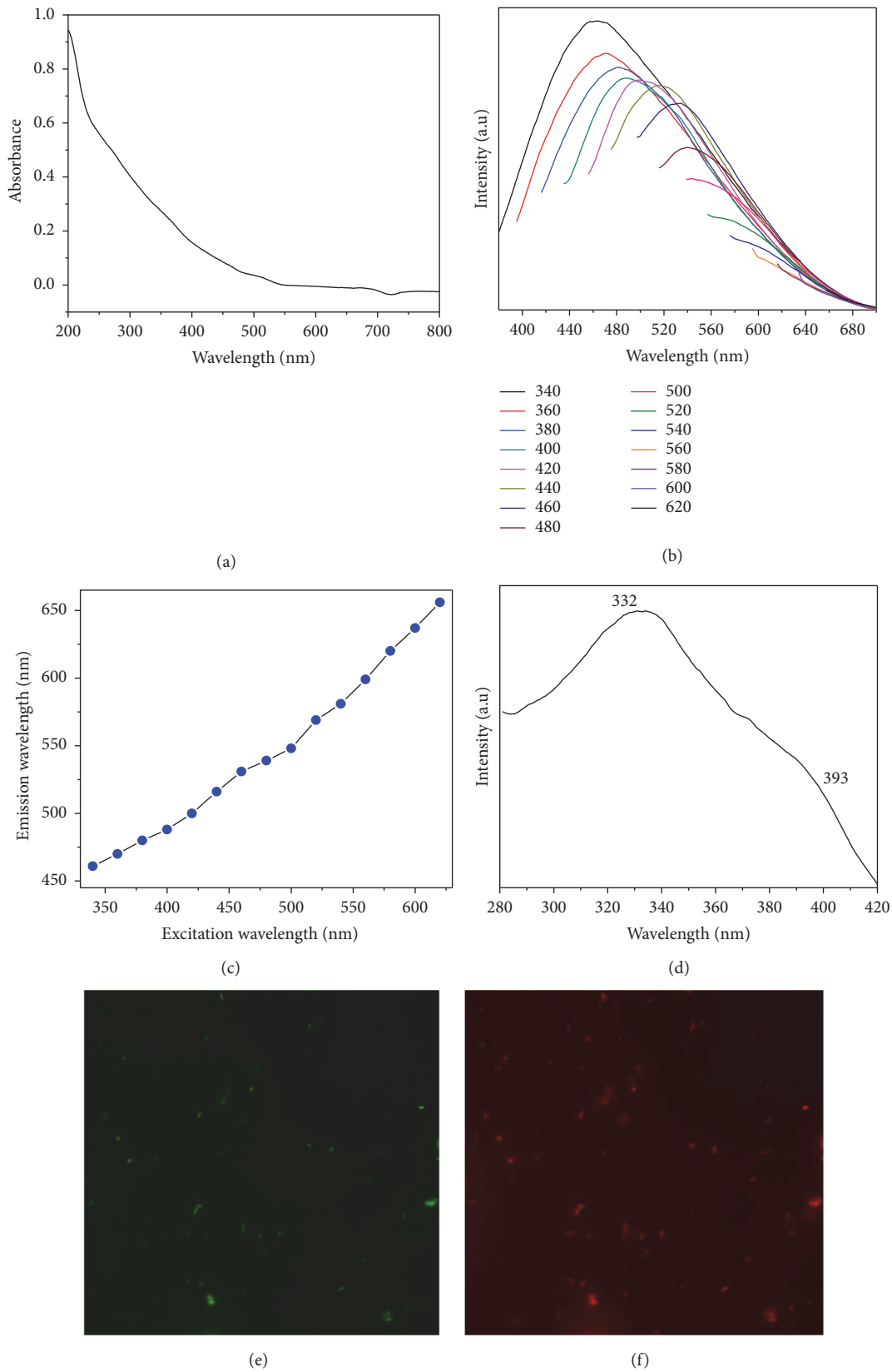

Figure 4: (a) Absorption spectra of wsCNDs; (b) tunable emission spectra of wsCNDs in the range of 340–620 nm excitation wavelength on a continuous increment of 20 nm; (c) variation in emissions center with excitation, λ_{em} was efficiently showing a bathochromic shift when move from one λ_{ex} to the next with 20 nm increment to track the shift in the PL spectrum with λ_{ex}, the data points were gets from panel (b); (d) photoluminescent excitation spectrum on 460 nm emission wavelength. Optical images of wsCNDs at (e) 488 nm (green) and (f) 561 nm (red) band pass filters, respectively.

[7] C. Xie, B. Nie, L. Zeng et al., "Core-shell heterojunction of silicon nanowire arrays and carbon quantum dots for photovoltaic devices and self-driven photodetectors," *ACS Nano*, vol. 8, no. 4, pp. 4015–4022, 2014.

[8] K. M. Tripathi and N. R. Gupta, "Nano-carbons from pollutant soot: a cleaner approach toward clean environment," in *Smart Materials for Waste Water Applications*, pp. 127–154, John Wiley & Sons, 2016.

[9] K. M. Tripathi, A. Bhati, A. Singh et al., "From the traditional way of pyrolysis to tunable photoluminescent water soluble carbon nano-onions for cell imaging and selective sensing of glucose," *RSC Adv.*, vol. 6, no. 44, pp. 37319–37329, 2016.

[10] A. Tyagi, K. M. Tripathi, and R. K. Gupta, "Recent progress in micro-scale energy storage devices and future aspects," *Journal of Materials Chemistry A*, vol. 3, no. 45, pp. 22507–22541, 2015.

[11] H. Zhu, W. Zhang, and S. F. Yu, "Realization of lasing emission from graphene quantum dots using titanium dioxide nanoparticles as light scatterers," *Nanoscale*, vol. 5, no. 5, pp. 1797–1802, 2013.

[12] X. Zhang, Y. Zhang, Y. Wang et al., "Color-switchable electroluminescence of carbon dot light-emitting diodes," *ACS Nano*, vol. 7, no. 12, pp. 11234–11241, 2013.

[13] H. Ding, F. Du, P. Liu, Z. Chen, and J. Shen, "DNA–carbon dots function as fluorescent vehicles for drug delivery," *ACS Applied Materials & Interfaces*, vol. 7, no. 12, pp. 6889–6897, 2015.

[14] P. G. Luo, F. Yang, S.-T. Yang et al., "Carbon-based quantum dots for fluorescence imaging of cells and tissues," *RSC Advances*, vol. 4, no. 21, pp. 10791–10807, 2014.

[15] G. E. Lecroy, S. K. Sonkar, F. Yang et al., "Toward structurally defined carbon dots as ultracompact fluorescent probes," *ACS Nano*, vol. 8, no. 5, pp. 4522–4529, 2014.

[16] M. Ghosh, S. K. Sonkar, M. Saxena, and S. Sarkar, "Carbon nano-onions for imaging the life cycle of Drosophila melanogaster," *Small*, vol. 7, no. 22, pp. 3170–3177, 2011.

[17] L. Cao, M. J. Meziani, S. Sahu, and Y.-P. Sun, "Photoluminescence properties of graphene versus other carbon nanomaterials," *Accounts of Chemical Research*, vol. 46, no. 1, pp. 171–180, 2013.

[18] H. Tetsuka, R. Asahi, A. Nagoya et al., "Optically tunable amino-functionalized graphene quantum dots," *Advanced Materials*, vol. 24, no. 39, pp. 5333–5338, 2012.

[19] P.-C. Hsu, Z.-Y. Shih, C.-H. Lee, and H.-T. Chang, "Synthesis and analytical applications of photoluminescent carbon nanodots," *Green Chemistry*, vol. 14, no. 4, pp. 917–920, 2012.

[20] K. M. Tripathi, T. Kim, D. Losic, and T. T. Tung, "Recent advances in engineered graphene and composites for detection of volatile organic compounds (VOCs) and non-invasive diseases diagnosis," *Carbon*, vol. 110, pp. 97–129, 2016.

[21] A. P. Demchenko and M. O. Dekaliuk, "The origin of emissive states of carbon nanoparticles derived from ensemble-averaged and single-molecular studies," *Nanoscale*, vol. 8, no. 29, pp. 14057–14069, 2016.

[22] Y. Hu, J. Yang, J. Tian, L. Jia, and J.-S. Yu, "Waste frying oil as a precursor for one-step synthesis of sulfur-doped carbon dots with pH-sensitive photoluminescence," *Carbon*, vol. 77, pp. 775–782, 2014.

[23] K. Wang, F. Guan, H. Li, M. Li, H. Feng, and H. Fan, "One-step synthesis of carbon nanodots for sensitive detection of cephalexin," *RSC Advances*, vol. 5, no. 26, pp. 20511–20515, 2015.

[24] A. Prasannan and T. Imae, "One-pot synthesis of fluorescent carbon dots from orange waste peels," *Industrial & Engineering Chemistry Research*, vol. 52, no. 44, pp. 15673–15678, 2013.

[25] K. M. Tripathi, A. Tyagi, M. Ashfaq, and R. K. Gupta, "Temperature dependent, shape variant synthesis of photoluminescent and biocompatible carbon nanostructures from almond husk for applications in dye removal," *RSC Adv.*, vol. 6, no. 35, pp. 29545–29553, 2016.

[26] S. K. Sonkar, M. Saxena, M. Saha, and S. Sarkar, "Carbon nanocubes and nanobricks from pyrolysis of rice," *Journal of Nanoscience and Nanotechnology*, vol. 10, no. 6, pp. 4064–4067, 2010.

[27] A. Pusztai, E. M. Clarke, T. P. King, and J. C. Stewart, "Nutritional evaluation of kidney beans (Phaseolus vulgaris): chemical composition, lectin content and nutritional value of selected cultivars," *Journal of the Science of Food and Agriculture*, vol. 30, no. 9, pp. 843–848, 1979.

[28] A. Bhati, A. Singh, K. M. Tripathi, and S. K. Sonkar, "Sunlight-induced photochemical degradation of methylene blue by water-soluble carbon nanorods," *International Journal of Photoenergy*, vol. 2016, Article ID 2583821, 8 pages, 2016.

[29] Y. Cui, C. Zhang, L. Sun, Z. Hu, and X. Liu, "Simple and efficient synthesis of strongly green fluorescent carbon dots with upconversion property for direct cell imaging," *Particle & Particle Systems Characterization*, vol. 32, no. 5, pp. 542–546, 2015.

[30] V. Georgakilas, J. A. Perman, J. Tucek, and R. Zboril, "Broad family of carbon nanoallotropes: classification, chemistry, and applications of fullerenes, carbon dots, nanotubes, graphene, nanodiamonds, and combined superstructures," *Chemical Reviews*, vol. 115, no. 11, pp. 4744–4822, 2015.

[31] M. A. Pimenta, G. Dresselhaus, M. S. Dresselhaus, L. G. Cançado, A. Jorio, and R. Saito, "Studying disorder in graphite-based systems by Raman spectroscopy," *Physical Chemistry Chemical Physics*, vol. 9, no. 11, pp. 1276–1291, 2007.

[32] T. Kim, G. Jung, S. Yoo, K. S. Suh, and R. S. Ruoff, "Activated graphene-based carbons as supercapacitor electrodes with macro- and mesopores," *ACS Nano*, vol. 7, no. 8, pp. 6899–6905, 2013.

[33] T. S. Tran, S. J. Park, S. S. Yoo, T.-R. Lee, and T. Kim, "High shear-induced exfoliation of graphite into high quality graphene by Taylor-Couette flow," *RSC Advances*, vol. 6, no. 15, pp. 12003–12008, 2016.

[34] T. Kim, H. Lee, J. Kim, and K. S. Suh, "Synthesis of phase transferable graphene sheets using ionic liquid polymers," *ACS Nano*, vol. 4, no. 3, pp. 1612–1618, 2010.

[35] V. Ramanan, S. K. Thiyagarajan, K. Raji, R. Suresh, R. Sekar, and P. Ramamurthy, "Outright green synthesis of fluorescent carbon dots from eutrophic algal blooms for in vitro imaging," *ACS Sustainable Chemistry & Engineering*, vol. 4, no. 9, pp. 4724–4731, 2016.

[36] S. K. Sonkar, K. M. Tripathi, and S. Y. Sarkar, "Ferromagnetic behaviour of anthropogenic multi-walled carbon nanotubes trapped in spider web indoor," *Journal of Nanoscience and Nanotechnology*, vol. 14, no. 3, pp. 2532–2538, 2014.

[37] K. M. Tripathi, A. K. Sonker, A. Bhati et al., "Large-scale synthesis of soluble graphitic hollow carbon nanorods with tunable photoluminescence for the selective fluorescent detection of DNA," *New Journal of Chemistry*, vol. 40, no. 2, pp. 1571–1579, 2016.

[38] Y.-P. Sun, B. Zhou, Y. Lin et al., "Quantum-sized carbon dots for bright and colorful photoluminescence," *Journal of the American Chemical Society*, vol. 128, no. 24, pp. 7756–7757, 2006.