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# Fluorescent Nanoparticles from Several Commercial Beverages: Their Properties and Potential Application for Bioimaging



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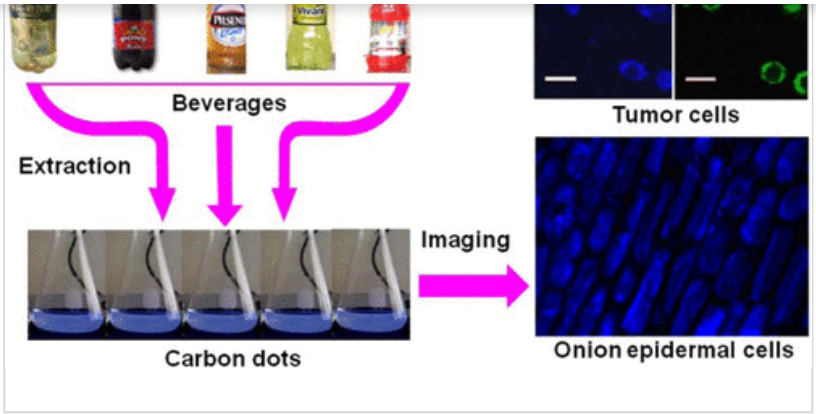
## Abstract




The presence of nanoparticles in beverages has raised great concern in terms of potential impacts to consumer health. Herein, carbon dots in beverages kvass, pony malta, pilsner beer, Vivant Storm, and Profit were identified. They were shown to have a strong fluorescence under the excitation of ultraviolet light. The emission peaks shift to longer wavelengths accompanied by a remarkable fluorescence intensity decrease. The carbon dots are in the nanosized range and roughly spherical in appearance. Elemental analysis by X-ray photoelectron spectroscopy demonstrated the composition of Kvass carbon dots to be C 83.17%, O 13.83%, and N 3.00%. No cytotoxicity was found at concentrations up to 20 mg/mL for human tongue squamous carcinoma cells, and they can be directly applied in both carcinoma and onion epidermal cell imaging. This work represents the first report of the carbon dots present in beverages, providing valuable insights into these nanoparticles for future biological imaging.



**Subjects**

Beverages Carbon Nanomaterials Fluorescence Food Quantum Dots

**Keywords**

Carbon Dots Beverage Cytotoxicity Fluorescence Bioimaging

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1. Anupam Ghosh, Krishna Gautam, Chandrika Gupta, Chinmay Hazra, Lopamudra Das, Nishant Chakravorty, Murali Mohan Mishra, Amit Nain, Sadasivam Anbumani, Chin-Jung Lin, Ramkrishna Sen, Nandita Dasgupta, Shivendu Ranjan. Single-Step Low-Temperature Synthesis of Carbon Dots for Advanced Multiparametric Bioimaging Probe Applications. *ACS Applied Bio Materials* **2024**, Article ASAP.

2. Boya Zhang, Ziteng Yu, Xinyi Zhao, Tianyue He, Xingpei Fan, Ruijiao Zhu, Yujie Feng, Weihong Lu, Dianpeng Qi, Xiao Ma, Ning Gu. Foodborne Carbon Dots Aggravate High-Fat-Diet-Induced Glucose Homeostasis Imbalance by Disrupting the Gut-Liver Axis. *ACS Applied Materials & Interfaces* **2024**, *16* (10) , 12263-12276. https://doi.org/10.1021/acsami.3c17656

3. Jian Chen, Yuxi Guo, Xianlong Zhang, Jianghua Liu, Pin Gong, Zhuoqun Su, Lihua Fan, Guoliang Li. Emerging Nanoparticles in Food: Sources, Application, and Safety. *Journal of Agricultural and Food Chemistry* **2023**, *71* (8) , 3564-3582. https://doi.org/10.1021/acs.jafc.2c06740

4. Melis Özge Alaş, Gamze Doğan, Mustafa Serkan Yalcin, Sadin Ozdemir, Rükan Genç. Multicolor Emitting Carbon Dot-Reinforced PVA Composites as Edible Food Packaging Films and Coatings with Antimicrobial and UV-Blocking Properties. *ACS Omega* **2022**, *7* (34) , 29967-29983. https://doi.org/10.1021/acsomega.2c02984

5. Ronggang Liu, Kangjing Liu, Guoxin Cui, Mingqian Tan. Change of Cell Toxicity of Food-Borne Nanoparticles after Forming Protein Coronas with Human Serum Albumin. *Journal of Agricultural and Food Chemistry* **2022**, *70* (4) , 1261-1271. https://doi.org/10.1021/acs.jafc.1c06814

6. Yun Ma, Zhi Ma, Xiyue Huo, Meiyu Gu, Sainan Ma, Yu Jing, Yixiao Wang, Ying Yue, Zhibiao Feng, Bo Tian. Efficient Imaging of Saccharomyces cerevisiae Based on B- and N-Doped Carbon Dots. *Journal of Agricultural and Food Chemistry* **2020**, *68* (37) , 10223-10231. https://doi.org/10.1021/acs.jafc.0c04251

7. Jiaxin Geng, Xunyu Song, Xuedi Zhang, Shanshan Tie, Lin Cao, Mingqian Tan. Hydrophilic Food-Borne Nanoparticles from Beef Broth as Novel Nanocarriers for Zinc. *Journal of Agricultural and Food Chemistry* **2019**, *67* (25) , 6995-7004. https://doi.org/10.1021/acs.jafc.9b01372

8. Xunyu Song, Lin Cao, Shuang Cong, Yukun Song, Mingqian Tan. Characterization of Endogenous Nanoparticles from Roasted Chicken Breasts. *Journal of Agricultural and Food Chemistry* **2018**, *66* (28) , 7522-7530. https://doi.org/10.1021/acs.jafc.8b01988

cinereus). *Journal of Agricultural and Food Chemistry* **2018**, *66* (11) , 2862-2869. https://doi.org/10.1021/acs.jafc.7b02303

10. Dongmei Li, Xiaokang Na, Haitao Wang, Yisha Xie, Shuang Cong, Yukun Song, Xianbing Xu, Bei-Wei Zhu, and Mingqian Tan . Fluorescent Carbon Dots Derived from Maillard Reaction Products: Their Properties, Biodistribution, Cytotoxicity, and Antioxidant Activity. *Journal of Agricultural and Food Chemistry* **2018**, *66* (6) , 1569-1575. https://doi.org/10.1021/acs.jafc.7b05643

11. Haitao Wang, Yisha Xie, Shan Liu, Shuang Cong, Yukun Song, Xianbing Xu, and Mingqian Tan . Presence of Fluorescent Carbon Nanoparticles in Baked Lamb: Their Properties and Potential Application for Sensors. *Journal of Agricultural and Food Chemistry* **2017**, *65* (34) , 7553-7559. https://doi.org/10.1021/acs.jafc.7b02913

12. Chenzhao Wang, Xiujuan Wang, Yuhao Jiang, Zhiyu Wu, Jiawei Yang, Shanshan Wei, Zhibing Wang, Guoying Sun. Ionic liquid-based yellow-emitting carbon dots for fluorescence-smartphone dual-mode detection of vitamin B6 in milk. *Food Chemistry* **2024**, *460* , 140525. https://doi.org/10.1016/j.foodchem.2024.140525

13. Ruchir Priyadarshi, Suzan Uzun, Jong-Whan Rhim. Edible coating using carbon quantum dots for fresh produce preservation: A review of safety perspectives. *Advances in Colloid and Interface Science* **2024**, *38* , 103211. https://doi.org/10.1016/j.cis.2024.103211

14. Chenzhao Wang, Xiujuan Wang, Yuhao Jiang, Zhiyu Wu, Jiawei Yang, Shanshan Wei, Zhibing Wang, Guoying Sun. Ionic Liquid-Based Yellow-Emitting Carbon Dots For Fluorescence-Smartphone Dual-Mode Detection Of Vitamin B6 in Milk. **2024**https://doi.org/10.2139/ssrn.4825354

15. Chen-Yow Wang, Nodali Ndraha, Ren-Siang Wu, Hsin-Yun Liu, Sin-Wei Lin, Kuang-Min Yang, Hung-Yun Lin. An Overview of the Potential of Food-Based Carbon Dots for Biomedical Applications. *International Journal of Molecular Sciences* **2023**, *24* (23) , 16579. https://doi.org/10.3390/ijms242316579

16. Chenzhao Wang, Junxian Li, Xiujuan Wang, Zhenjie Zhao, Runxiang Yao, Yuhao Jiang, Shanshan Wei, Zhibing Wang, Guoying Sun. Reusable red emission carbon dots based smartphone sensing platform for three-mode on-site real-time detection of alcohol content. *Sensors and Actuators B: Chemical* **2023**, *397* , 134690. https://doi.org/10.1016/j.snb.2023.134690

18. Qing Huang, Lixia Yan, Haodong Wei, Xingjian Ye, Wenlong Wang, Cheng Yang, Xiu-Ping Yan, Yi Zhang. Extraction, characterization and toxicity evaluation of fluorescent carbon nanoparticles in bamboo charcoal peanut. *Journal of Food Composition and Analysis* **2023**, *121* , 105357. https://doi.org/10.1016/j.jfca.2023.105357

19. Sobiya Manzoor, Aamir Hussain Dar, Kshirod Kumar Dash, Vinay Kumar Pandey, Shivangi Srivastava, Iqra Bashir, Shafat Ahmad Khan. Carbon dots applications for development of sustainable technologies for food safety: A comprehensive review. *Applied Food Research* **2023**, *3* (1) , 100263. https://doi.org/10.1016/j.afres.2023.100263

20. Chenzhao Wang, Xiujuan Wang, Yupu Zhang, Yihuan Tang, Yi Yang, Bin Wang, Shanshan Wei, Zhibing Wang, Guoying Sun. Ionic liquid-based carbon dots as highly biocompatible and sensitive fluorescent probe for the determination of vitamin P in fruit samples. *Food Chemistry* **2023**, *406* , 134898. https://doi.org/10.1016/j.foodchem.2022.134898

21. Gwajeong Jeong, Chan Ho Park, Dongchan Yi, Hyunseung Yang. Green synthesis of carbon dots from spent coffee grounds via ball-milling: Application in fluorescent chemosensors. *Journal of Cleaner Production* **2023**, *392* , 136250. https://doi.org/10.1016/j.jclepro.2023.136250

22. Boya Zhang, Lidong Yu, Ruijiao Zhu, Xiangjuan Wei, Xingpei Fan, Hailong Hu, Daqian Yang, Haining Du, Meimei Zhao, Li Li, Yuri Oh, Yujie Feng, Ning Gu. Malting barley carbon dots-mediated oxidative stress promotes insulin resistance in mice via NF-κB pathway and MAPK cascade. *Journal of Nanobiotechnology* **2022**, *20* (1) https://doi.org/10.1186/s12951-022-01543-1

23. Parya Ezati, Ruchir Priyadarshi, Jong-Whan Rhim. Prospects of sustainable and renewable source-based carbon quantum dots for food packaging applications. *Sustainable Materials and Technologies* **2022**, *33* , e00494. https://doi.org/10.1016/j.susmat.2022.e00494

24. Xunyu Song, Yukun Song, Zixuan Guo, Mingqian Tan. Influence of protein coronas between carbon nanoparticles extracted from roasted chicken and pepsin on the digestion of soy protein isolate. *Food Chemistry* **2022**, *385* , 132714. https://doi.org/10.1016/j.foodchem.2022.132714

25. Wenyu Zhao, Yi Zhang, Bin Cao, Zhuoyan Li, Chengfeng Sun, Xiaolin Cao, Shuang Cong. Characteristics of Mussels-Derived Carbon Dots and Their Applications in Bio-Imaging and Detection of Riboflavin. *Foods* **2022**, *11* (16) , 2451. https://doi.org/10.3390/foods11162451

photosynthesis and nutrient uptake. *Environmental Science: Nano* **2022**, *9* (5) , 1651-1661. https://doi.org/10.1039/D1EN01079D

27. Jing Hu, Wenyi Jia, Xinyi Wu, Haiyun Zhang, Yin Wang, Junfeng Liu, Yu Yang, Shu Tao, Xilong Wang. Carbon dots can strongly promote photosynthesis in lettuce ( Lactuca sativa L.). *Environmental Science: Nano* **2022**, *9* (4) , 1530-1540. https://doi.org/10.1039/D1EN00948F

28. Saptarshi Mandal, Prolay Das. Are carbon dots worth the tremendous attention it is getting: Challenges and opportunities. *Applied Materials Today* **2022**, *26* , 101331. https://doi.org/10.1016/j.apmt.2021.101331

29. Qingshu Li, Li Yuan, Yongfeng Liu. Effects of adding sodium nitrite and tea polyphenols on the characterizations and cytotoxicity of carbon nanoparticles from fried pork. *Food Chemistry* **2021**, *365* , 130464. https://doi.org/10.1016/j.foodchem.2021.130464

30. Shao-Chieh Yen, Ju-Yi Mao, Hung-Yun Lin, Huai-Ting Huang, Scott G. Harroun, Amit Nain, Huan-Tsung Chang, Han-You Lin, Li-Li Chen, Chih-Ching Huang, Han-Jia Lin. Multifunctional carbonized nanogels to treat lethal acute hepatopancreatic necrosis disease. *Journal of Nanobiotechnology* **2021**, *19* (1) https://doi.org/10.1186/s12951-021-01194-8

31. Lijuan Liu, Shengting Zhang, Xiaodan Zheng, Hongmei Li, Qi Chen, Kunhao Qin, Yafang Ding, Yunlin Wei. Carbon dots derived from Fusobacterium nucleatum for intracellular determination of Fe 3+ and bioimaging both in vitro and in vivo. *Analytical Methods* **2021**, *13* (9) , 1121-1131. https://doi.org/10.1039/D1AY00020A

32. Lin Cao, Jiaqi Li, Yukun Song, Shuang Cong, Haitao Wang, Mingqian Tan. Molecular interaction of fluorescent carbon dots from mature vinegar with human hemoglobin: Insights from spectroscopy, thermodynamics and AFM. *International Journal of Biological Macromolecules* **2021**, *167* , 415-422. https://doi.org/10.1016/j.ijbiomac.2020.11.203

33. João Otávio Donizette Malafatti, Thamara Machado de Oliveira Ruellas, Mariana Rodrigues Meirelles, Adriana Coatrini Thomazi, Carmen Greice Renda, Elaine Cristina Paris, , , , . Nanocarriers of Eu<sup>3+</sup> doped silica nanoparticles modified by APTES for luminescent monitoring of cloxacillin. *AIMS Materials Science* **2021**, *8* (5) , 760-775. https://doi.org/10.3934/matersci.2021046

34. Bin Lai, Guoxin Cui, Haitao Wang, Yukun Song, Mingqian Tan. Identification of fluorescent nanoparticles from roasted sweet potato (Ipomoea batatas) during normal cooking procedures. *LWT* **2020**, *134* , 109989.

35. Haitao Wang, Wentao Su, Mingqian Tan. Endogenous Fluorescence Carbon Dots Derived from Food Items. *The Innovation* **2020**, *1* (1) , 100009. https://doi.org/10.1016/j.xinn.2020.04.009

36. Fatemeh Radnia, Nasrin Mohajeri, Nosratollah Zarghami. New insight into the engineering of green carbon dots: Possible applications in emerging cancer theranostics. *Talanta* **2020**, *209* , 120547. https://doi.org/10.1016/j.talanta.2019.120547

37. Emine Yavuz, Saliha Dinc, Meryem Kara. Effects of endogenous molasses carbon dots on macrophages and their potential utilization as anti-inflammatory agents. *Applied Physics A* **2020**, *126* (1) https://doi.org/10.1007/s00339-019-3189-1

38. M.A. Ríos-Corripio, A.S. López-Díaz, N. Ramírez-Corona, A. López-Malo, E. Palou. Metallic Nanoparticles: Development, Applications, and Future Trends for Alcoholic and Nonalcoholic Beverages. **2020**, 263-300. https://doi.org/10.1016/B978-0-12-816677-2.00009-0

39. Xue-Di Zhang, Jun Li, Jia-Ning Niu, Xuan-Ping Bao, Hai-Dong Zhao, Mingqian Tan. Fluorescent carbon dots derived from urine and their application for bio-imaging. *Methods* **2019**, *168* , 84-93. https://doi.org/10.1016/j.ymeth.2019.04.005

40. Yukun Song, Xintong Li, Shuang Cong, Haidong Zhao, Mingqian Tan. Nuclear-targeted of TAT peptide-conjugated carbon dots for both one-and two-photon fluorescence imaging. *Colloids and Surfaces B: Biointerfaces* **2019**, *180* , 449-456. https://doi.org/10.1016/j.colsurfb.2019.05.015

41. Jiaqi Li, Lin Cao, Dongmei Li, Chenxu Yu, Mingqian Tan. Carbon dots from roasted mackerel (scomberomorus niphonius) for free radical scavenging. *LWT* **2019**, *111* , 588-593. https://doi.org/10.1016/j.lwt.2019.05.073

42. Dongmei Li, Yisha Xie, Xiaokang Na, Yao Li, Chengbo Dai, Yulian Li, Mingqian Tan. Insights into melanoidin conversion into fluorescent nanoparticles in the Maillard reaction. *Food & Function* **2019**, *10* (7) , 4414-4422. https://doi.org/10.1039/C9FO00383E

43. Haitao Wang, Yisha Xie, Xiaokang Na, Jingran Bi, Shan Liu, Lijuan Zhang, Mingqian Tan. Fluorescent carbon dots in baked lamb: Formation, cytotoxicity and scavenging capability to free radicals. *Food Chemistry* **2019**, *286* , 405-412. https://doi.org/10.1016/j.foodchem.2019.02.034

*& Function* **2019**, *10* (5) , 2408-2416. https://doi.org/10.1039/C8FO01944D

45. Clara Deeney, Eoin P. McKiernan, Samir A. Belhout, Brian J. Rodriguez, Gareth Redmond, Susan J. Quinn. Template-Assisted Synthesis of Luminescent Carbon Nanofibers from Beverage-Related Precursors by Microwave Heating. *Molecules* **2019**, *24* (8) , 1455. https://doi.org/10.3390/molecules24081455

46. Dongmei Li, Xiaokang Na, Wanru Zhou, Congcong Wang, Yuliang Li, Bei-Wei Zhu, Mingqian Tan. Adverse effects of fluorescent carbon dots from canned yellow croaker on cellular respiration and glycolysis. *Food & Function* **2019**, *10* (2) , 1123-1131. https://doi.org/10.1039/C8FO02602E

View

47. Haitao Wang, Shan Liu, Yukun Song, Bei-Wei Zhu, Mingqian Tan. Universal existence of fluorescent carbon dots in beer and assessment of their potential toxicity. *Nanotoxicology* **2019**, *13* (2) , 160-173. https://doi.org/10.1080/17435390.2018.1530394

View

48. Liszulfah Roza, Permono Adi Putro, Isnaeni. Ultrasonic-assisted melt blending for polyvinyl alcohol/carbon dots luminescent flexible films. **2019**, 060008. https://doi.org/10.1063/1.5132686

View

49. Xunyu Song, Haitao Wang, Run Zhang, Chenxu Yu, Mingqian Tan. Bio-distribution and interaction with dopamine of fluorescent nanodots from roasted chicken. *Food & Function* **2018**, *9* (12) , 6227-6235. https://doi.org/10.1039/C8FO01159A

View

50. Lizhen Zhang, Zhaoxing Lin, Yun-Xiang Yu, Bang-Ping Jiang, Xing-Can Shen. Multifunctional hyaluronic acid-derived carbon dots for self-targeted imaging-guided photodynamic therapy. *Journal of Materials Chemistry B* **2018**, *6* (41) , 6534-6543. https://doi.org/10.1039/C8TB01957F

View

51. Vijay Mishra, Akshay Patil, Sourav Thakur, Prashant Kesharwani. Carbon dots: emerging theranostic nanoarchitectures. *Drug Discovery Today* **2018**, *23* (6) , 1219-1232. https://doi.org/10.1016/j.drudis.2018.01.006

View

52. Alina A. Kokorina, Ekaterina S. Prikhozhdenko, Nadezda V. Tarakina, Andrei V. Sapelkin, Gleb B. Sukhorukov, Irina Y. Goryacheva. Dispersion of optical and structural properties in gel column separated carbon nanoparticles. *Carbon* **2018**, *127* , 541-547. https://doi.org/10.1016/j.carbon.2017.11.039

Coca-Cola and Pepsi-Cola: physicochemical properties, cytotoxicity, biodistribution and digestion studies. *Nanotoxicology* **2018**, *12* (1) , 49-62. https://doi.org/10.1080/17435390.2017.1418443

View

54. Mittal L. Desai, Sanjay Jha, Hirakendu Basu, Rakesh Kumar Singhal, P. K. Sharma, Suresh Kumar Kailasa. Microwave-assisted synthesis of water-soluble Eu 3+ hybrid carbon dots with enhanced fluorescence for the sensing of Hg 2+ ions and imaging of fungal cells. *New Journal of Chemistry* **2018**, *42* (8) , 6125-6133. https://doi.org/10.1039/C7NJ04835A

View

55. Dik-Lung Ma, Chun Wu, Wei Tang, Ashwin-Rajesh Gupta, Fu-Wa Lee, Guodong Li, Chung-Hang Leung. Recent advances in iridium( iii ) complex-assisted nanomaterials for biological applications. *Journal of Materials Chemistry B* **2018**, *6* (4) , 537-544. https://doi.org/10.1039/C7TB02859H

View

56. Shuang Cong, Jingran Bi, Xunyu Song, Chenxu Yu, Mingqian Tan. Ultrasmall fluorescent nanoparticles derived from roast duck: their physicochemical characteristics and interaction with human serum albumin. *Food & Function* **2018**, *9* (4) , 2490-2495. https://doi.org/10.1039/C8FO00178B

View

57. Yiwen Ji, Yiqun Zhou, Eric Waidely, Alexandra Desserre, M. Hensley Marksberry, Charles C. Chusuei, Aijaz Ahmad Dar, Oyais Ahmad Chat, Shanghao Li, Roger M. Leblanc. Rheology of a carbon dot gel. *Inorganica Chimica Acta* **2017**, *468* , 119-124. https://doi.org/10.1016/j.ica.2017.07.046

View

58. Qiankun Zhu, Xiaoming Li, Yonghua Xiao, Yan Xiong, Suiping Wang, Changli Xu, Jun Zhang, Xuewen Wu. Synthesis of Molecularly Imprinted Polymer via Visible Light Activated RAFT Polymerization in Aqueous Media at Room Temperature for Highly Selective Electrochemical Assay of Glucose. *Macromolecular Chemistry and Physics* **2017**, *218* (19) https://doi.org/10.1002/macp.201700141

View

59. Melis Ozge Alas, Rukan Genc. An investigation into the role of macromolecules of different polarity as passivating agent on the physical, chemical and structural properties of fluorescent carbon nanodots. *Journal of Nanoparticle Research* **2017**, *19* (5) https://doi.org/10.1007/s11051-017-3863-1

View

60. Yiqun Zhou, Alexandra Desserre, Shiv K. Sharma, Shanghao Li, M. Hensley Marksberry, Charles C. Chusuei, Patricia L. Blackwelder, Roger M. Leblanc. Gel-like Carbon Dots: Characterization and their Potential Applications. *ChemPhysChem* **2017**, *18* (8) , 890-897. https://doi.org/10.1002/cphc.201700038

View

61. Yao Li, Jingran Bi, Shan Liu, Haitao Wang, Chenxu Yu, Dongmei Li, Bei-Wei Zhu, Mingqian Tan. Presence and formation of fluorescence carbon dots in a grilled hamburger. *Food & Function* **2017**, *8* (7) , 2558-2565.

62. Lin Cao, Xunyu Song, Yukun Song, Jingran Bi, Shuang Cong, Chenxu Yu, Mingqian Tan. Fluorescent nanoparticles from mature vinegar: their properties and interaction with dopamine. *Food & Function* **2017**, *8* (12) , 4744-4751. https://doi.org/10.1039/C7FO01475A

View

63. Bingyan Han, Mingbo Yu, Tingting Pen, Ying Li, Xixi Hu, Rongchao Xiang, Xufen Hou, Gaohong He. One-step extraction of highly fluorescent carbon quantum dots by a physical method from carbon black. *New Journal of Chemistry* **2017**, *41* (13) , 5267-5270. https://doi.org/10.1039/C7NJ00858A

View

64. Jingran Bi, Yao Li, Haitao Wang, Yukun Song, Shuang Cong, Dongmei Li, Dayong Zhou, Bei-Wei Zhu, Mingqian Tan. Physicochemical properties and cytotoxicity of carbon dots in grilled fish. *New Journal of Chemistry* **2017**, *41* (16) , 8490-8496. https://doi.org/10.1039/C7NJ02163A

View

65. Jingran Bi, Haitao Wang, Tariq Kamal, Bei-Wei Zhu, Mingqian Tan. A fluorescence turn-off-on chemosensor based on carbon nanocages for detection of ascorbic acid. *RSC Advances* **2017**, *7* (48) , 30481-30487. https://doi.org/10.1039/C7RA04394E

View

66. Jilong Wang, Jingjing Qiu. A review of carbon dots in biological applications. *Journal of Materials Science* **2016**, *51* (10) , 4728-4738. https://doi.org/10.1007/s10853-016-9797-7

View

67. Qianfang Yao, Yang Zheng, Wenyu Cheng, MengJun Chen, Jie Shen, Meizhen Yin. Difunctional fluorescent HSA modified CoFe 2 O 4 magnetic nanoparticles for cell imaging. *Journal of Materials Chemistry B* **2016**, *4* (38) , 6344-6349. https://doi.org/10.1039/C6TB01787H

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