# Highly emissive carbon nanodots for multicolor chemiluminescence and multi-photon upconversion fluorescence

With the support by the National Natural Science Foundation of China, the research team led by Prof. Shan ChongXin (单崇新) at Zhengzhou University demonstrated bright multicolor chemiluminescent and multi-photon excited red/near-infrared emissive carbon nanodots (CNDs), which were published in *Advanced Science* (2019, 6: 1802331, and 2019, 6: 1900766), respectively.

Carbon nanodots (CNDs), as a kind of rising star nanomaterial of carbon family, have high emission efficiency, good biocompatibility, and tunable emission, which makes them a promising candidate in bioimaging, sensing, optoelectronics, anti-fake, and photocatalysis. Most of the reports focus on their fluorescence, while very few reports on their chemiluminescence and multi-photon excited red/near-infrared fluorescence can be found to date.

In this study, researchers from Prof. Shan's group demonstrated blue, green, and red chemiluminescence from CNDs by tuning the conjugated sp2-domain size under different solvent conditions. A chemiluminescence quantum yield of $9.32\times10^{-3}$ Einsteins $mol^{-1}$, maximal luminance of 3.28 cd $m^{-2}$, and lifetime of 186.4 s were achieved in red CNDs, all of which are the best values ever reported for CNDs. As a proof-of-concept prototype, a high quality information encryption strategy has been established via CND-based imaging techniques by virtue of the high brightness and multicolor chemiluminescence.

Additionally, researchers from Prof. Shan's group prepared red/near-infrared emissive CNDs via an *in situ* solvent-free carbonization strategy, and the photoluminescence quantum yield can reach up to 57%. Because of large tissue penetration and high spatial resolution of light with long wavelength, 1-photon and 2-photon cellular imaging was demonstrated by using the CNDs as red/ NIR fluorescence agent due to the high quantum efficiency and low biotoxicity. Further study shows that the red/NIR CNDs exhibit multiphoton excited upconversion fluorescence under the excitation of 800—2 000 nm, which involves three NIR windows (NIR-I, 650—950 nm; NIR-II, 1 100—1 350; NIR-III, 1 600—1 870 nm). Two-photon, 3-photon, and 4-photon excited fluorescence of the CNDs was achieved.

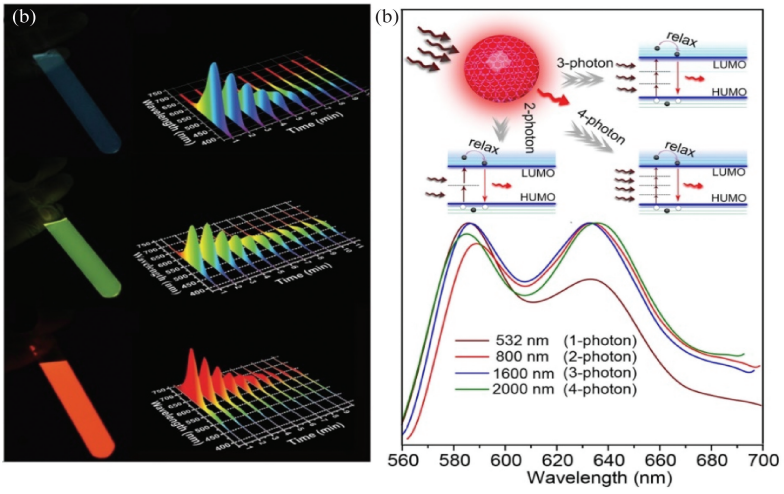


**Figure** The photograph, CL decay spectra (a) and multi-photon fluorescence of the CNDs (b).