Investigation of the Carbon Dots Optical Properties Using Laser Scanning Confocal Microscopy and TimE-resolved Fluorescence Microscopy

Authors : M. S. Stepanova, V. V. Zakharov, P. D. Khavlyuk, I. D. Skurlov, A. Y. Dubovik, A. L. Rogach

Abstract : Carbon dots are small carbon-based spherical nanoparticles, which are typically less than 10 nm in size that can be modified with surface passivation and heteroatoms doping. The light-absorbing ability of carbon dots has attracted a significant amount of attention in photoluminescence for bioimaging and fluorescence sensing applications owing to their advantages, such as tunable fluorescence emission, photo- and thermostability and low toxicity. In this study, carbon dots were synthesized by the solvothermal method from citric acid and ethylenediamine dissolved in water. The solution was heated for 5 hours at 200°C and then cooled down to room temperature. The carbon dots films were obtained by evaporation from a high-concentration aqueous solution. The increase of both luminescence intensity and light transmission was obtained as a result of a 405 nm laser exposure to a part of the carbon dots film, which was detected using a confocal laser scanning microscope (LSM 710, Zeiss). Blueshift up to 35 nm of the luminescence spectrum is observed as luminescence intensity, which is increased more than twofold. The exact value of the shift depends on the time of the laser exposure. This shift can be caused by the modification of surface groups at the carbon dots, which are responsible for long-wavelength luminescence. In addition, a shift of the absorption peak by 10 nm and a decrease in the optical density at the wavelength of 350 nm is detected, which is responsible for the absorption of surface groups. The obtained sample was also studied with time-resolved confocal fluorescence microscope (MicroTime 100, PicoQuant), which made it possible to receive a time-resolved photoluminescence image and construct emission decays of the laser-exposed and non-exposed areas. 5 MHz pulse rate impulse laser has been used as a photoluminescence excitation source. Photoluminescence decay was approximated by two exhibitors. The laser-exposed area has the amplitude of the first-lifetime component (A1) twice as much as before, with increasing $\tau 1$. At the same time, the second-lifetime component (A2) decreases. These changes evidence a modification of the surface groups of carbon dots. The detected effect can be used to create thermostable fluorescent marks, the physical size of which is bounded by the diffraction limit of the optics (~ 200-300 nm) used for exposure and to improve the optical properties of carbon dots or in the field of optical encryption. Acknowledgements: This work was supported by the Ministry of Science and Higher Education of Russian Federation, goszadanie no. 2019-1080 and financially supported by Government of Russian Federation, Grant 08-08.
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