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Synthesis and study of optical properties of reduced graphene oxide quantum dots

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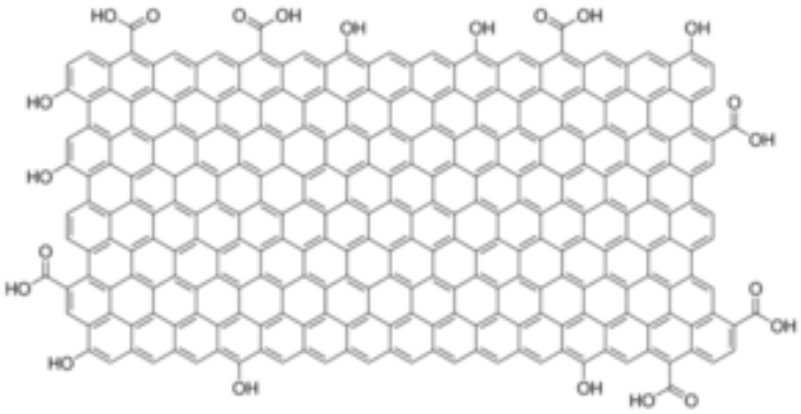
Graphene and carbon quantum dots posses a high solubility in water, chemical inertness and resistance to photobleaching. They are very promising for use in photocatalysis and photovoltaics, as well as for use in biophysics and medicine, due to their low toxicity and high biocompatibility.

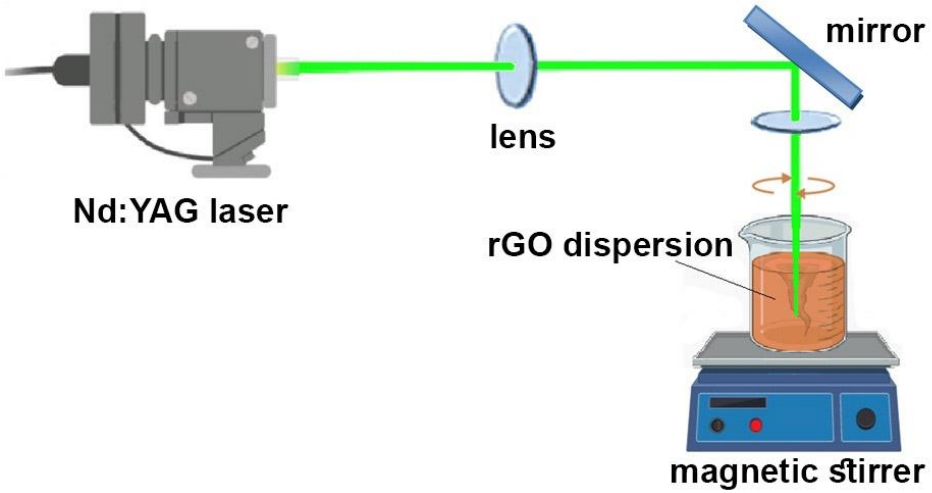
In this work, quantum dots based on reduced graphene oxide (rGO) were prepared, and their structural and optical properties were studied.



Structure of reduced graphene oxide

"Reduced graphene oxide (rGO) is the form of graphene oxide that is processed by chemical, thermal and other methods in order to reduce the oxygen content, while graphite oxide is a material produced by oxidation of graphite which leads to increased interlayer spacing and functionalization of the basal planes of graphite."

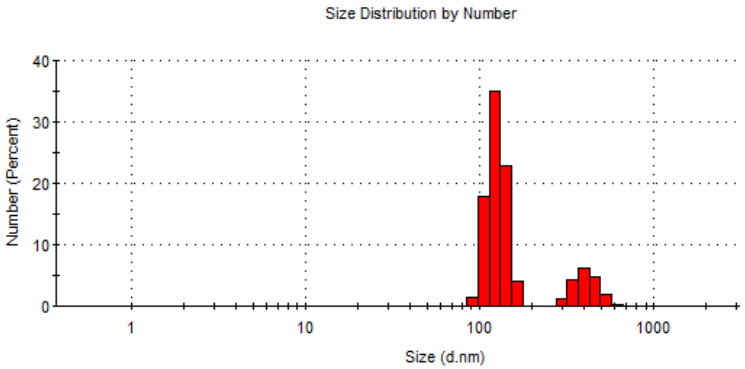
From: Carbon, 2015
https://www.sciencedirect.com/topics/materials-science/



Scheme of installation for laser ablation

Quantum dots were obtained by laser ablation of reduced graphene oxide (rGO, Sigma Aldrich) in ethanol. The rGO concentration was equal to 0.3 mg/mL. The dispersions were sonicated for 30 minutes.

Ablation was carried out by irradiating of the dispersions by Nd:YAG laser with λ=532 nm, a pulse duration τ = 10 nm and a pulse energy of ~16 J/cm^2. The ablation time was equal to 20 minutes. The height of the ablated solution was 0.5 cm, during the laser ablation liquid the dispersion was continuously mixed.

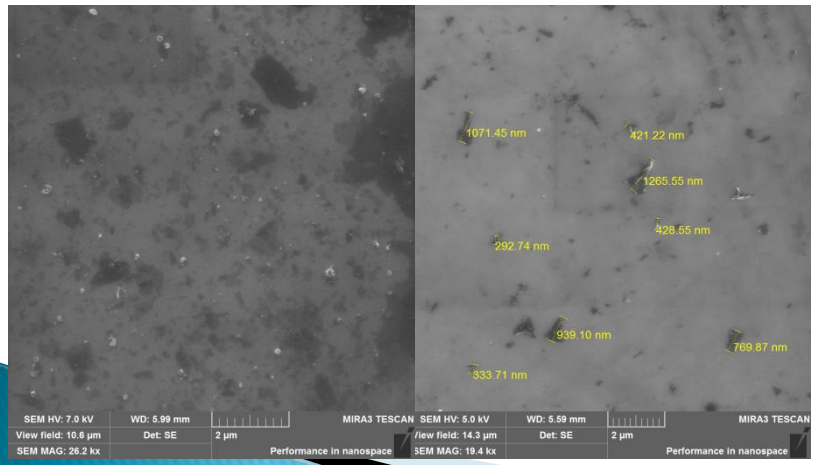


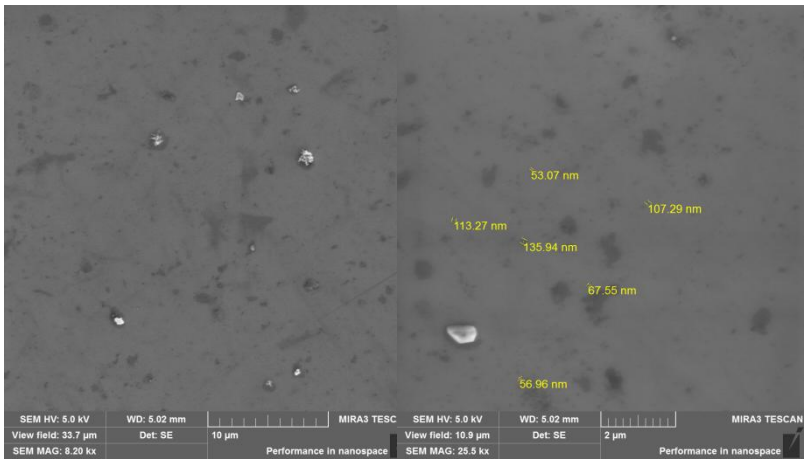
Size distribution of rGO after ablation

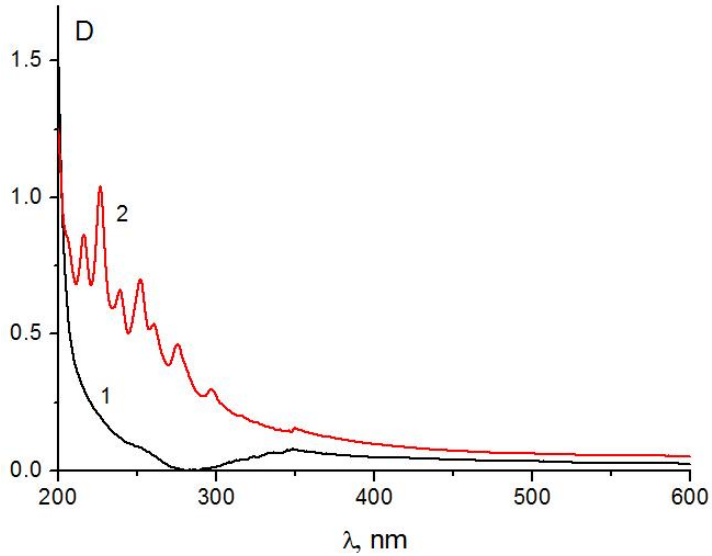
Dynamic light scattering measurements (Zetasizer S90, Malvern) showed that the average particle size before ablation was equal to 250±85 nm.

After ablation, the particle size was decreased to 130±27 nm. SEM images (Mira 3MLU, Tescan) also identified particles with an average diameter of 59±7 nm.

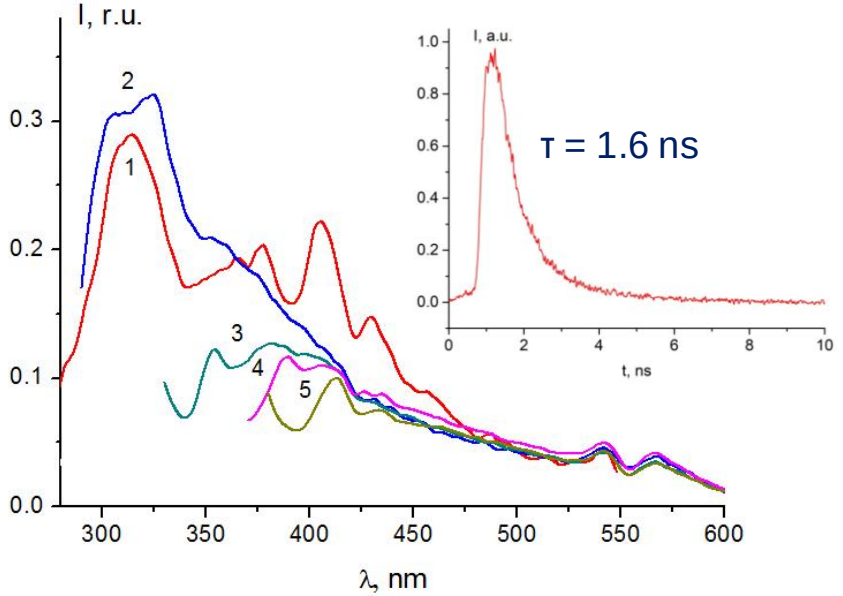
SEM images of rGO before (left) and after (right) ablation







Absorption spectra of rGO before (1) and after (2) ablation



Fluorescence spectra of rGO after ablation under photoexcitation at, nm: 1 – 260; 2 – 275; 3 – 320; 4 – 350; 5 – 370. In the inset – fluorescence decay kinetics at 390 nm.

The highest luminescence intensity was registered upon photoexcitation of the sample with wavelengths in the range upon of 250 nm. In this case, the vibrational structure was practically not revealed in the fluorescence spectrum. Bands with maxima at 300, 330, 350, and 400 nm can be distinguished in the spectra. It should be noted that, upon excitation of rGO dispersions at 250 nm, vibrational peaks characteristic of aromatic compounds appear in the spectrum.

The absorption and fluorescence spectra of the samples were measured on Cary and Eclipse spectrometers (Agilent), respectively. Fluorescence lifetimes were measured with TCSPC system (Becker&Hickl).

Conclusions

- Effect of laser irradiation on structure and optical properties of reduced graphene oxide (rGO) was studied.
- After laser ablation, a significant decrease in the size of rGO sheets from 250±85 nm to 130–60 nm was observed.
- The fluorescence of rGO was registered in the region of 250–500 nm. Bands with maxima at 300, 330, 350, and 400 nm can be distinguished in the spectra. The maximum fluorescence intensity was recorded at λ_{exc}=275 nm. The fluorescence lifetime of rGO was equal to 1.6 ns.
- The fluorescence excitation spectra indicate that the main contribution to rGO luminescence comes from centers actively absorbing light in the 260–300 nm region of spectra.

The results obtained can be used to create organic luminescent materials, optical nanotechnology, as well as in photovoltaics, biophysics, and bioimaging.

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Thanks for the attention!