

Graphene Oxide Sol-Gel Fabrication by Ultrafast Laser Ablation

Mehrdad Irannejad¹, Khaled M. Ibrahim¹, Ali Ramadhan², Mojtaba Hajjalamdari², Joseph Sanderson², Mustafa Yavuz¹

¹Waterloo Institute for Nanotechnology, University of Waterloo 200 University Ave W., Waterloo, ON, Canada.

² Department of Physics, University of Waterloo, 200 University Ave W., Waterloo, ON, Canada

Mehrdad.Irannejad@uwaterloo.ca

Abstract

3D graphene oxide gel (GOG) and GO sol-gel (GOSG) have promising potential in a wide range of applications from drug delivery to energy storage and bio-/chemical sensors[1] due to their exceptional electrical, optical and mechanical properties. The GOG and GOSG can be formed in many ways such as conventional hydrothermal method, acidification of GO[2, 3], and self-assembly of supramolecular interactions[1]. In this work, the GOSG and were fabricated by direct exposure of high intensity ultrafast laser pulses from an fs laser generated by a Ti: Sapphire ultrafast regenerative amplifier. The laser parameter was fixed as central wavelength of 800 nm, pulse width of 35 fs, repetition rate of 1 kHz. The laser pulse energy was varied in the range of 250 μ J to 2mJ. The incident beam was focused on the surface of the GO solution (Fig.1a) using a 5cm and 10 cm biconvex lens. Focusing the laser beam on the solution surface resulted in the production of an enormous electric field on the GO solution/air interface ($\sim 10^{19}$ V.cm⁻¹). As a result of the surface exposure, the carboxyl (COOH) bonds between the GO sheets were broken and hence, the π - π interactions between the aromatic sheets of GO were increased resulting in a reduction of the repulsion electrostatic interactions among the GO sheets leading to the formation of GO sol-gel and GO hydrogel after 8 min exposure. The Raman spectra of unexposed GO, GOSG and exposed GO irritated solution by focusing the laser beam inside the solution are compared in Fig.1b-1d. It was found that the I_D/I_G ratio was increased compared to the unexposed GO solution, which could be attributed to the increase of dislocations and hole doping within the hexagonal honeycomb structure of the GO sheets. It was found that the absorbance intensity of $\pi \rightarrow \pi^*$ transition in the -C=C bond (at $\lambda=230$ nm) and the $n \rightarrow \pi^*$ transitions in the -C=O ($\lambda=300$ nm) was increased in the GOSG, compared to the unexposed GO solution. This increase in the absorbance spectrum could be attributed to the formation of sp³ carbon-carbon and carbonyl bonds because of the vaporization of H₂O and converting the carboxyl bonds to carbonyl bonds. Further characterization such as XPS, XRD and surface morphology including AFM and SEM have confirmed the GOSG and hydrogel formation via the π - π stacking interaction.

References

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Figures

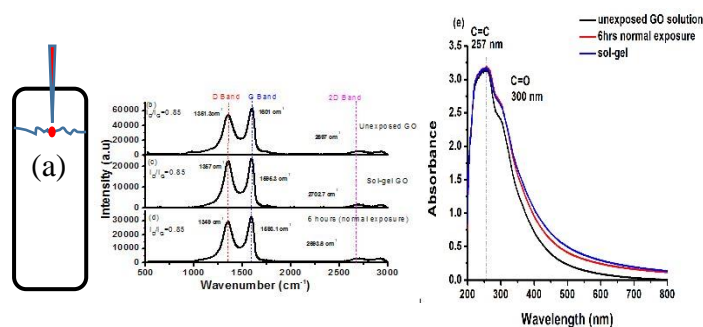


Fig. (a) Schematic illustration of laser beam focusing on the GO solution and air interface. Recorded Raman spectra of (b) unexposed GO solution, (c) GOSG, (d) GO solution after 8 min exposure, (e) UV-VIS spectrum of unexposed GO, exposed GO solutions and GOSG.