Understanding the Photophysics, Synthesis, and Doping Effects of Graphene Quantum Dots

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Abstract

Graphene quantum dots (GQDs) are an emerging class of carbon nanomaterials that exhibit interesting optical properties allowing applications in photovoltaics, photocatalysis, light emitting diodes, sensing, and bioimaging. The photoluminescence (PL) of GQDs is influenced by both sizes of sp^2 carbon domains through the quantum confinement effect and localized defect states due to surface functional groups. Therefore, it is desirable to produce GQDs with controlled sizes and functional groups to tune the PL. Traditional methods to produce GQDs suffer limitations including uses of harsh chemicals, toxic side products, and inhomogeneity in their sizes and functional groups. Liquid-phase laser ablation is a promising alternative method for GQD formation which utilizes fewer chemicals, forms fewer side products, requires simple purification methods, and allows improved control over the sizes and functional groups. During liquid-phase laser ablation, a solid target of carbon precursor is irradiated with a high-power, nanosecond pulsed laser, forming plasma plumes that expand, are cooled by the surrounding liquid, and condense into carbon nanoparticles. It was observed that GQDs produced through liquid-phase laser ablation of carbon nano-onions in water resulted in a blue shifted PL, smaller particle size, and a larger concentration of surface hydroxyl groups, compared to those produced through a traditional chemical oxidation method. PL lifetime results from time-correlated single photon counting measurements indicate that surface functional groups are the primary source of radiative deactivation while sp^2 carbon domains are weakly emitting. Alternative precursors, such as biomass and petroleum coke, can be used for GQD formation. Moreover, the laser ablation method can directly incorporate nitrogen atoms from solutes in the liquid into GQDs, allowing for fast nitrogen doping which tunes the PL, adds new catalytic sites, and increases the PL quantum yield.

Biography of Presenter

Rosemary Calabro is a PhD candidate in the Department of Chemistry at University of Kentucky. She received her Bachelors of Science at Indiana University where she researched iron oxide based bimetallic nanoparticles under the advising of Dr. Lyudmila Bronstein. She joined the University of Kentucky in 2014 and is advised by Dr. Doo Young Kim and Dr. Dong-Sheng Yang. Her research interests include physical-materials chemistry with an emphasis on photoluminescent carbon materials, upconverting nanomaterials, and applying liquid phase-laser ablation as a new method to produce nanomaterials.