Graphene Quantum Dots Embedded in a Polymer Film

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Graphene quantum dots (GQDs) are a few nanometer sized pieces of graphene sheet that exhibit photoluminescence (PL) in the visible region, as well as unique electron transport and superior mechanical properties. The PL originates from large edge effects and exhibits strong quantum confinement effects. The intrinsic characteristics of GQD can be applied to various devices, e.g., light emitters, optoelectronic devices and photovoltaics. The technique to embed GQDs in a solid material is indispensable for realizing GQD-based devices. Here we report a simple method that produces a GQD-polymer composite film by drying a mixture solution of GQD and poly-vinyl alcohol (PVA). GQDs were homogeneously dispersed in the film, which was measured by absorption and Raman spectroscopy. The PL of GQDs in the film was also investigated. The simple technique enables the development of GQD-based composites for numerous applications of GQDs.

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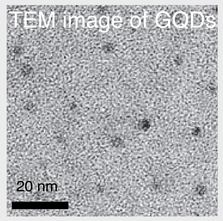
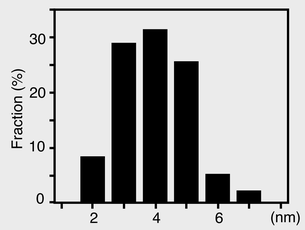
Introduction: Graphene Quantum Dots

Graphene Quantum Dots (GQDs) are a few nanometer sized pieces of graphene sheet that exhibit photoluminescence (PL) in the visible region due to size effects and quantum confinements, as well as unique electron transport and superior mechanical properties.





Y. Li et.al., *Adv.Mater.*,**23**, 776 (2011)

GQDs in water

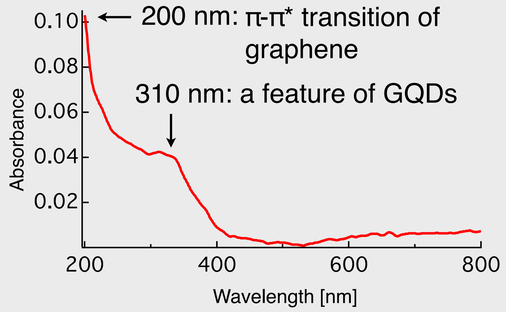
Daylight UV light

Purpose: To develop a GQD/Polymer composite

We aim to develop a simple method that produces a GQD-polymer composite. Here we demonstrate the composite film by drying a mixture solution of GQD and poly-vinyl alcohol (PVA). The PL of GQD/PVA composite film and the temperature-dependence of PL intensity are investigated.

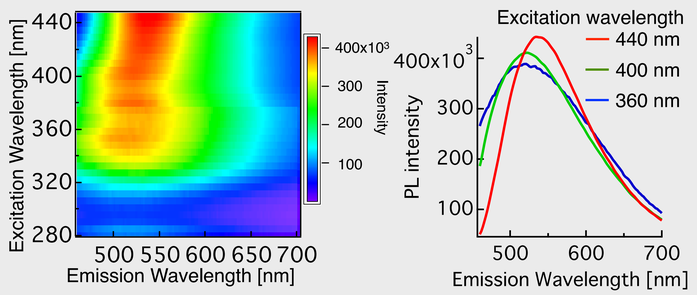
Absorption and Photoluminescence of GQDs in water

Absorption of GQDs



The absorbance peak at 310 nm is a feature of GQDs due to quantum confinement effects and edge effects.

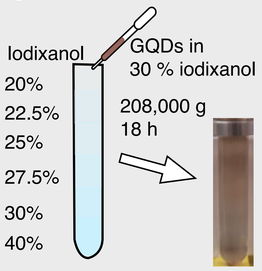
Photoluminescence of GQDs



GQDs exhibit PL in the visible region, which depends on the excitation wavelength. The dependence of PL could be attributed to the size effect of GQDs.

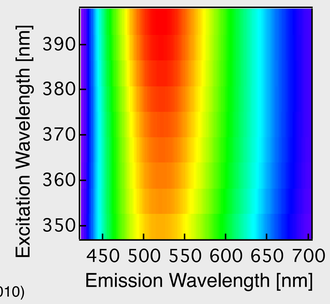
Density Gradient Ultracentrifugation (DGU) for the size-separation

GQDs in density gradient medium

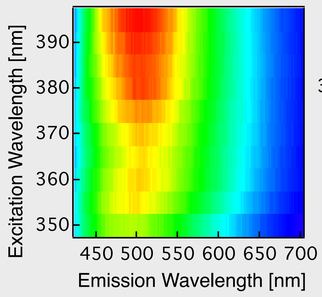


E. Haroz et.al., *ACS Nano*, **4**, 1955 (2010)

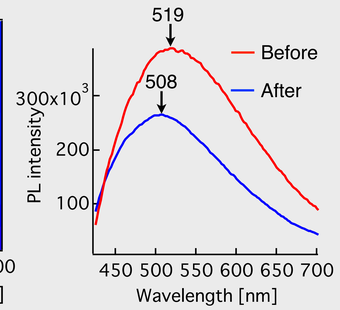
Before DGU



After DGU



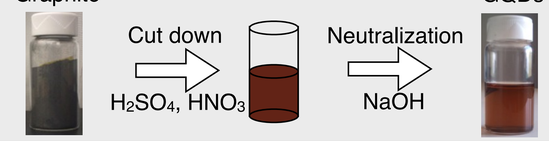
PL spectra at 380 nm



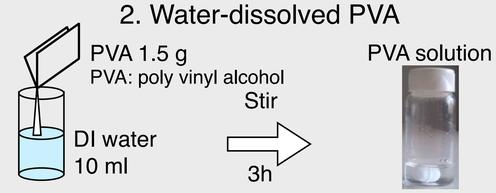
PL peaks were significantly blue-shifted by 10 nm after DGU. DGU could remove large-diameter GQDs and/or aggregated GQDs.

Fabrication Procedure: GQD/PVA composite film

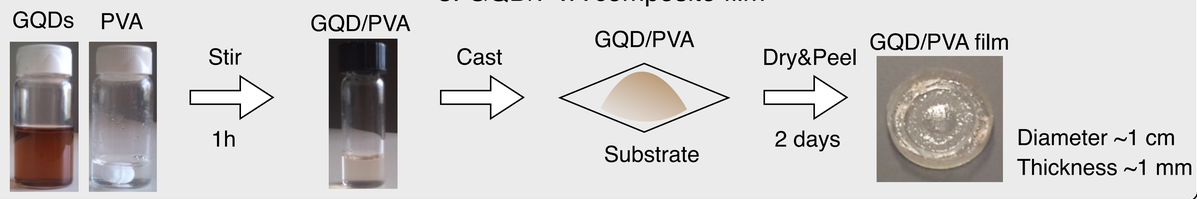
1. Chemical Synthesis of GQDs



2. Water-dissolved PVA

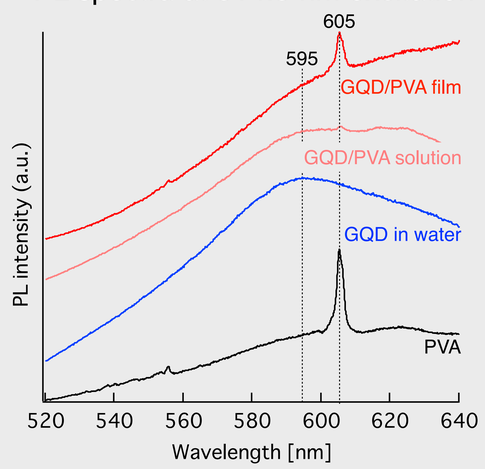


3. GQD/PVA composite film



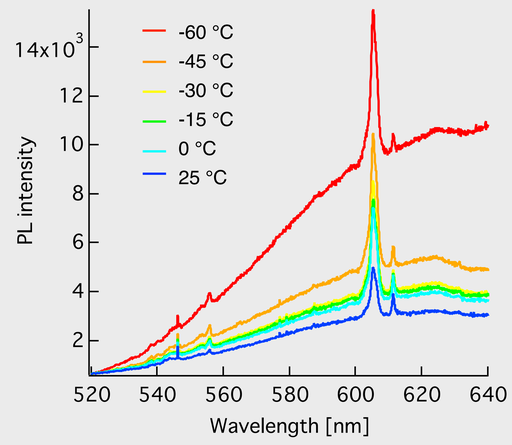
PL characterization of GQD/PVA composite film

PL spectra at 514.5 nm excitation



PL of the GQDs at 595 nm was suppressed when the GQDs were embedded in the film. The intensity decrease is probably related to the decrease of the concentration, the aggregation and in particular energy transfer to the polymer.

Temperature-dependence of the PL intensity



The overall PL intensity increased with decrease temperature. The enhancement originated from the suppression of thermal quenching.

Y. Sun et.al., *Acc. Chem.Res.*, **35**, 1096 (2002)
D. Valerini et.al., *Phys. Rev. B*, **71**, 235409 (2005)

Summary

GQD/Polymer composites were developed by the simple method. The PL from GQD/PVA composite film was suppressed, but enhanced with decrease of temperature.

Acknowledgement

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