Facile synthesis of graphene quantum dots by microplasma-assisted electrochemistry

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Graphene quantum dots (GQDs) have attracted more attentions due to their superior advantages such as good bio-compatibility, high photostability and tunable optical properties. These properties make it be able to substitute for conventional fluorescent nanomaterials. Currently, most synthesis methods involve high temperature, costly and complex processes unfavorable to its development. Here we report a facile and rapid process to synthesize GQDs through a microplasma-assisted electrochemistry method. And also, we provide a methodology to study physical and chemical effects on the photoluminescence properties.

Microplasmas are defined as gaseous discharges formed in electrode geometries where at least one dimension is less than 1mm. It can be operated with an aqueous solution as an electrode. Energetic species including radicals, ions and electrons formed in the microplasma are capable of initiating electrochemical or non-electrochemical reactions below the electrolyte. Detailed materials characterizations including various spectroscopies and microscopies suggest the developed microplasma-assisted electrochemistry method possess the ability to produce GQDs. The analytic results demonstrate as-product have blue emission with quantum yield of closing 1.5%. Raman spectrum show G, D and 2D band signals typical for carbon containing materials. Size distribution from TEM imaging show an average size of 4.9 nm. Its PL properties exhibit excitation-dependent emission, suggesting microplasma technology can possibly control its surface state and structure. Moreover, we also investigate its physical and chemical effects towards GQDs PL properties by adjusting plasma operating conditions and various precursors in the electrolytes, respectively. Increasing exposure time consequently shifts GQDs PL peak to the red spectrum suggesting particle size is increased, with reference to the quantum confinement theory. Similar effect is observed for using amine precursors having COOH functional groups as it generate more defects on GQDs surface, thus emitting lower energy. Our study provides the insight to understand the fundamental factors to control the GQDs emission energies.

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