Multiphoton Fluorescence Spectroscopy in Conjunction with Activated Graphene Quantum Dots for Monitoring Tissue Regeneration and Drug Delivery

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Abstract

Graphene quantum dots (GQDs) with enhanced optical, electrochemical and biomedical properties are poised to revolutionise the design and fabrication of devices for a range of applications.[1] Recent advances in GQD synthesis has been based on modifying their surface states,[2,3] while a few studies suggest that the edge-states[4] and the structure of their edges[5] contribute towards their photoluminescence. Graphene as a non-toxic, biocompatible material relative to inorganic quantum dots (QDs) such as CdS and CdSe have been receiving substantial interest due to their exceptional luminescence and band-gap tuning capabilities for applications in biomedical imaging.[6] The shape and reduced size of GQDs offer substantial advantages over graphene in terms of edge sites and biomedical applications.[7]

The activated functionalized graphene quantum dots (aGQDs) we synthesized were characterized by edge-bound nano-sizes and presented extra-bright luminescence due to quantum confinement and edge effects. Our solvo-thermal approach coupled with chemical activation generated aGQDs with BET surface area enhanced by a factor of six and photoluminescence intensity augmented by a factor of five compared to its non-activated counterparts. Bright field scanning transmission electron microscopy (ABF-STEM) indicated that the activation process generated networks of nano-pores within the aGQDs. High resolution TEM image showed a narrow size distribution between 1–8 nm. Raman and XPS spectroscopy confirmed the structural and chemical composition of the aGQDs, and the electrical properties were characterized using cyclic voltammetetry and electrical impedance spectroscopy (EIS).

The new generation of aGQDs we synthesized were tested using multiphoton spectroscopy for bio-imaging suitable for monitoring scaffold and tissues for regenerative medicine. The *in-vitro* tests with HeLa cell lines showed that there was minimal cytoxicity due to the aGQDs. Further tests were performed to establish protocols for the use of the quantum dots for simultaneous delivery of drugs at targeted sites and monitoring the effects due to the administration of drugs such as doxorubicin for the treatment of cancer.

References

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