IVYSPRING INTERNATIONAL PUBLISHER

Theranostics

2012; 2(7):629-630. doi: 10.7150/thno.4757

Editorial

Quantum Dots for Biophotonics

Ken-Tye Yong ✉

School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798, Singapore

✉ Corresponding author: ktyong@ntu.edu.sg

Received: 2012.06.18; Accepted: 2012.06.19; Published: 2012.07.04

Abstract

This theme issue provides an excellent collection of reviews and original research articles on the study of various bioconjugated quantum dot formulations for diagnostics and therapy applications using biophotonic imaging and sensing approaches.

Key words: Quantum dots, Quantum rods, surface functionalization, bioimaging, biosensing, gene/drug delivery, nanotoxicity

When the diameter of a semiconductor crystal becomes smaller than the Bohr exciton radius of the material from which it is made, the energy levels (conduction and valence bands in the bulk) become size dependent and are increasingly made up of discrete states rather than continuous energy bands. Such semiconductor nanocrystals are known as "Quantum Dots" (QDs). QDs are luminescent semiconductor nanocrystals with sizes ranging from 3 to 10 nm. Also, QDs can be made to emit wavelengths ranging from 450 to 1600 nm by changing their size, shape, and composition. These "tiny" crystals composed of hundreds to thousands of atoms, and may be made up of group II-VI elements, group III-V elements, group IV-VI elements, or group IV elements alone. Due to their unique tunable spectral and optoelectronic properties, they have been extensively employed for various biomedical and medicinal research applications [1].

Biophotonics is an expanding frontier of science that employs light for medical diagnostics and imaging, biosensing, laser tissue engineering, and light activated therapy. Biophotonics involves the study of light activated processes at both cellular and tissue levels. Quantum dots possess unique optical properties that make them powerful candidates as probes or carriers for in vitro and in vivo research and bioimaging applications. The surface of quantum dots can be engineered with functional biomolecules to selectively target specific sites in vitro and in vivo. For example, bioconjugated quantum dots have been used in targeted cell labeling, tissue imaging, photodynamic therapy, in vivo tumor detection, and drug delivery [2,3]. The flexibility and versatility of quantum dots may provide the keys to answer important biological questions and ultimately improve diagnostics and therapy of human diseases. A synergistic combination of quantum dots with biophotonics provides unprecedented opportunities for addressing many of the current challenges in disease diagnosis and therapy. The main objectives of this special issue are not only to highlight the development of QDs for biophotonics, but also to explore the challenges and opportunities we face while utilizing them for in vitro and in vivo imaging and sensing research.

This theme collection of articles first introduces the current status of QDs in biophtonics and nanomedicine field followed by targeted imaging and therapy applications of QDs. Various designs of QD formulations, including CdSe quantum dots, CdTe/ZnS core/shell QDs, CdTe/ZnTe core/shell QDs, CdSe/CdS/ZnS quantum rods, PbS QDs, and the combination of QD surface functionalization strategies have been used for in vitro and in vivo imaging studies. As for therapy applications, QDs can serve as a carrier for delivering drug and gene therapeutics. This theme issue consists of 4 reviews, 5 original research articles and was contributed by prominent researchers in QD imaging and therapy research.

Zhang and Huang [4] started with a description of using QDs for molecular sensing and diagnostics applications. Baba and Nishida [5] reviewed different approaches of employing QDs for single-molecule tracking in living cells. Clift and Stone [6] focused on the biological interaction of QDs and their relevance to clinical use. Yong et al. [7] summarized the recent development of QD/drug nanoparticle formulations for traceable targeted delivery and therapy applications. Different "packaging" methods for preparing QD/drug formulations are also briefly discussed. Law et al. [8] reported the use of functionalized quantum rods in gene silencing of human neuronal cells for treating drug addiction. Liu et al. [9] reported on the use of bioconjugated Pluronic triblock-copolymer micelle-encapsulated QDs for targeted cancer imaging. In this study, the authors showed that folic acid (FA) molecule can be conjugated to QDs for the targeted delivery to the tumor site upon exploiting the overexpressed FA receptors (FARs) on the tumor cells. Kumar et al. [10] demonstrated the engineering of theranostic polymeric micelles that are composed of both QDs and anticancer drug molecules for imaging and therapy of cancer. Hu et al. [11] reported the use of functionalized near-infrared PbS QDs for in vitro and in vivo imaging studies. They have shown that the toxicity of PbS QDs can be significantly reduced upon encapsulating the nanocrystals surface with Pegylated phospholipids micelle. Finally, Xu et al. [12] evaluated the invasion and reproductive toxicity of QD bioconjugates on preantral follicle in vitro model. The authors have established a preantral follicle in vitro culture system to investigate the effects of QD bioconjugates on the follicle development and oocyte maturation. This study will lay an import foundation for future study of the reproductive effect and toxicological mechanism of nanomaterials.

Overall, this is an excellent collection of reviews and research articles that reports an overview on the study of various bioconjugated quantum dot formulations for diagnostics and therapy applications using biophotonic imaging and sensing approaches. I sincerely thank all the authors for contributing their discoveries on this special theme issue that will pave the way for future development of "safe" quantum dots for clinical applications.

Competing Interests

The author has declared that no competing interest exists.

References

1. Yong K-T, Roy I, Swihart MT, Prasad PN. Multifunctional nanoparticles as biocompatible targeted probes for human cancer diagnosis and therapy. *J Mater Chem*. 2009; 19: 4655-72 doi:10.1039/B817667C
2. Kim GB, Kim YP. Analysis of protease activity using quantum dots and resonance energy transfer. *Theranostics*. 2012; 2(2): 127-138 doi:10.7150/thno.3476
3. Cao L, Yang ST, Wang X, Luo PG, Liu JH, Sahu S, Liu Y, Sun YP. Competitive performance of carbon "quantum" dots in optical bioimaging. *Theranostics*. 2012; 2(3): 295-301 doi:10.7150/thno.3912
4. Zhang Y, Wang T-H. Quantum dot enabled molecular sensing and diagnostics. *Theranostics*. 2012; 2(7): 631-654. doi:10.7150/thno.4308
5. Baba K, Nishida K. Single-molecule tracking in living cells using single quantum dot applications. *Theranostics*. 2012; 2(7): 655-667. doi:10.7150/thno.3890
6. Clift MJD, Stone V. Quantum dots: An insight and perspective of their biological interaction and how this relates to their relevance for clinical use. *Theranostics*. 2012; 2(7): 668-680. doi:10.7150/thno.4545
7. Yong K-T, Wang Y, Roy I. *et al*. Preparation of quantum dot/drug nanoparticle formulations for traceable targeted delivery and therapy. *Theranostics*. 2012; 2(7): 681-694. doi:10.7150/thno.3692
8. Law WC, Mahajan SD, Kopwitthaya A. *et al*. Gene silencing of human neuronal cells for drug addiction therapy using anisotropic nanocrystals. *Theranostics*. 2012; 2(7): 695-704. doi:10.7150/thno.3459
9. Liu L, Yong K-T, Roy I. *et al*. Bioconjugated pluronic triblock-copolymer micelle-encapsulated quantum dots for targeted imaging of cancer: in vitro and in vivo studies. *Theranostics*. 2012; 2(7): 705-713. doi:10.7150/thno.3456
10. Kumar R, Kulkarni A, Nagesha DK, Sridhar S. In vitro evaluation of theranostic polymeric micelles for imaging and drug delivery in cancer. *Theranostics*. 2012; 2(7): 714-722. doi:10.7150/thno.3927
11. Hu R, Law WC, Lin G. *et al*. PEGylated phospholipid micelle-encapsulated near-infrared PbS quantum dots for in vitro and in vivo bioimaging. *Theranostics*. 2012; 2(7): 723-733. doi:10.7150/thno.4275
12. Xu G, Lin S, Law WC. *et al*. The invasion and reproductive toxicity of QDs-transferrin bioconjugates on preantral follicle in vitro. *Theranostics*. 2012; 2(7): 734-745. doi:10.7150/thno.4290