

Quantum dots as biological optical imaging tools

Abstract

Quantum dots are semiconducting nanocrystals having dimensions in the range of 2-10 nanometers that have attracted for their clinical and diagnostic applications. Their surface modification or functionalization has been in significant progress over last decades to make them precise nanoprobe for biological imaging. This practice is carried out with bioconjugation of prepared quantum dots in to various biological/chemical molecules with broad absorption spectra, bright emission and photophysical robustness. This surface modified quantum dots might be further improved tool for brain targeted or cell imaging for getting accurate localization of tumor or diseased tissues to achieve effective diagnostic biopsy and complete surgical resection for improved surgical management of brain or cell tumors as improved optical imaging and optical spectroscopy tools.

Keywords: quantum dots, nanoparticles, brain imaging, optical imaging tools, bioconjugation, tumor, polyethylene glycol

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Introduction

Quantum dots (QDs) are semiconducting nanosized particles material having dimensions in the range of 2-10 nanometers which were first discovered in 1980. In addition, very tiny nanosized QDs can be easily incorporated into a cellular membrane that have low toxicity and possess an intrinsic sensitivity to surrounding electric fields.¹⁻³ Quantum dots (QDs) have been subjected for optical imaging as effective nanoscale semiconductors which have unique photophysical properties.⁴ The application of quantum dots (QDs) have been considered for imaging for neuronal action potentials to achieve better resolution imaging tool to analysis brain cell function.^{5,6} The intraoperative diagnosis of brain tumors or diseased cells and accurate evaluation of their biomarkers can be improved diagnostic to prepare precise guidelines for arranging rapid adjunctive clinical and biomedical studies. This was evaluated for specificity of using of streptavidin-coated conjugated anti-EGFR antibodies quantum dot-labeled antibodies quantum dots (QDs) for rapid visualization of epidermal growth factor receptor (EGFR) expression in human brain tumor cells and human glioma tumor cell lines.⁷

Previously, semiconductor and fluorescent quantum dots (QDs) were considered improved optical imaging tools with their surface modifications for surgical management of brain tumors. The intravenous injection of quantum dots was used with reticuloendothelial system and macrophage sequestration for getting improved brain imaging mapping for tracking the optically labeling the tumors. So, macrophage-mediated delivery of quantum dots to brain tumors might be novel biomedical technique to label tumors or diseased preoperatively through which tumors or any type of diseased cells or tissues may be detected with optical imaging to provide the surgeon with real-time optical feedback during the resection and biopsy of brain tumors or diseased cells/tissues.⁸

Surface modification and functionalization of quantum dots (QDs) may improve their water solubility via using the organometallic processes which protect them from any kind degradation and fluorescence quenching. In addition, their surface modification with polyethylene glycol (PEG) was found to minimize their non-

specific uptake in normal organs and provide functional groups for further choosing any bioconjugation process.⁹ Delivery of imaging agents or vectors to the brain is very important for the accurate diagnosis and treatment of various central nervous system (CNS) disorders or neurodegenerative diseases to examine their respective pathophysiology. Optically active modified quantum dots (QDs) might be prove more promising nano-probe with unique physical, chemical, and optical properties for molecular and cellular imaging apart their poor stability and low blood-brain barrier permeability. So, recently, quantum dots (QDs) based cell or biological optical imaging concept was developed for brain and cell imaging by incorporating quantum dots (QDs) into the core of poly (ethylene glycol)-poly(lactic acid) nanoparticles with their surface fabrication with wheat germ agglutinin which were further delivered into the brain or cells via nasal administration route. The resulting surface modified quantum dots (QDs) were found to notices to have increased payload capacity, better aqueous solubility and more safe brain or cells imaging properties.¹⁰

Conclusion

The short and precise review article can helpful to provide instant layout to describe the application of quantum dots (QDs) in brain and cell imaging as more efficient optical tools as well as to make them more multifunctional nanoprobe by employing various surface modifications and bioconjugation processes. So, use of functionalized quantum dots (QDs) can be considered more promising nano-labeled-probes for improving their applicability in brain and cell imaging to treat many neurodegenerative or central nervous system disorders and tumors.

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Conflict of interest

The author declares no conflict of interest.

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