Quantum Dots Based Drug Delivery

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Abstract
For long-term, multiplexed, and quantitative imaging and detection, quantum dots have demonstrated their effectiveness as fluorescent probes. The transport of drugs in cells and small animals may be studied using newly developed quantum dots with integrated targeting, imaging, and therapeutic functions. In addition to serving as a superior substitute for magnetic and radioactive imaging contrast ants in preclinical drug screening, validation, and delivery research, this fluorescent "prototype" will contribute significant knowledge to the rational design of biocompatible drug carriers.

Keywords: Biomedical, Quantum Dots, Drug Delivery

Introduction
Quantum dots (QDs), also known as semiconductor nanocrystals, are now a crucial component of biomedical research, particularly for multiplexed, quantitative, and long-term fluorescence imaging and detection. The fundamental justification for adopting QDs comes from their exceptional and intriguing optical features, which are often not present in individual molecules or bulk semiconductor materials. QDs differ from typical organic dyes and fluorescent proteins in that they can emit light of varying sizes, have better signal brightness, are resistant to photobleaching, and may simultaneously excite many different fluorescence colours.As a result of the success of employing QDs in biological imaging, sensing, and detection, researchers are working to advance this technology for use in clinical and translational studies.Because it has the ability to clarify the pharmacokinetics and pharmacodynamics of drug candidates and to give the design principles for drug carrier engineering, traceable drug delivery looks to be one of the most significant upcoming uses of QDs. QDs are currently only used in cell and small animal applications due to worries about long-term in vivo toxicity and degradation. Traceable therapeutic delivery in cells and animals, however, continues to have a significant influence on life science research, including drug development, validation, and delivery. This is due to the frequent use of cells and small animals in the testing of medication candidates. It takes specialised imaging techniques to follow drug molecules or drug carriers non-invasively and in real time in living creatures.Because optical imaging is very sensitive, quantitative, multiplexing capability, and far less expensive than conventional imaging modalities like MRI and positron emission tomography, it will dramatically cut the cost and lengthen the time needed in developing novel drugs. QDs can therefore serve as an ideal "prototype" for the creation and optimisation of nano-carriers, from which biocompatible carriers with comparable sizes and surface characteristics can be created for use in clinical applications [1, 2].

Quantum dots as Carriers
Due to the aforementioned optical characteristics, molecular imaging and sensing are the main focus of current biomedical applications of QDs. In recent years, structural

characteristics of QDs—which may be as important—have come to light in studies on drug delivery. First, the diameter of QDs, which typically ranges from 5 to 20 nm after polymer encapsulation, may be constantly controlled between 2 and 10 nm. While larger particles are more likely to be absorbed by the reticuloendothelial system before reaching the intended disease sites, smaller particles are promptly removed by renal filtration. Additionally, deeper tissue penetration by bigger particles is constrained.Scientists will be able to determine the ideal dimensions of drug carriers thanks to recent developments in the synthesis of QD nanocrystals, which will enable them to rigorously evaluate the size influence on delivery efficiency and specificity. Second, while maintaining the total size within the ideal range, numerous functions may be linked on a single QD due to the high surface-to-volume ratio of nanomaterials. This completely integrated nanostructure may act like a magic wand that can not only recognise, attach to, and heal sick cells but also produce signals that can be detected for real-time trajectory tracking [3].

Quantum Dots as Drug Carriers

A traditional drug carrier can be marked with QDs, which act as photostable fluorescent reporters, enabling the second type of QD application in traceable drug delivery. Fewer modern drug carriers are based on inorganic substances than polymers like poly(lactic-co-glycolic acid) and polyethyleneimine. This delivery method's absence of an inherent signal for long-term and in-the-moment imaging of drug transport is a typical drawback. Conjugation using organic fluorophores has helped to solve some of this issue. However, long-term monitoring or imaging are not possible due to the photobleaching issue that virtually all organic dyes have.Due to their distinctive spectral characteristics, QDs are an obvious choice in this situation. Indeed, with a recent surge in effort in the field of ODN and siRNA delivery, they have been utilised to mark both organic and inorganic drug carriers as well as maybe even bacteria and viruses. QDs have already contributed significantly to fundamental biology, in vitro disease diagnostics, and prognostics as potent imaging probes. Targeted and traceable drug delivery has become a new area of study thanks to these materials' distinctive structural and surface features, including their programmable and uniform size, adaptable drug linking and doping processes, high surface-to-volume ratios, and broad range of surface reactive groups.High-quality QDs, on the other hand, are mostly produced using heavy metals whose long-term toxicity is essentially unknown at this moment (visible and near-infrared dots with a narrow emission profile and high quantum yield). Despite this drawback, QDs have been used to deliver drugs to cells and small animals, acting as a superb discovery tool for drug screening and validation as well as as a model material for the creation of drug carriers. The therapeutic significance of QDs may be foreseen if high-quality QDs can be produced from comparatively non-toxic substances or if toxic components can be inertly shielded from exposure and afterwards eliminated from the body. Maintaining a relevant concentration of the medication in the targeted tissue while avoiding toxicity is one of the key challenges of drug delivery [4].

The modified QDs would ideally be able to stabilise therapeutic compounds, lengthen the duration they spend in the plasma while decreasing the concentration of free drug to lessen undesirable side effects, and release the medication with a carefully regulated profile. Additionally, the targeted and therapeutic chemicals may be chemically covalently attached to the QD surface in order to make the bioconjugates first big enough to bypass renal filtration and then small enough to be excreted from the body once the ligands are broken. These multipurpose, intelligent, low- or non-toxic nanomachines are only a few potential future developments.The QD-based bionanotechnology will

continue to grow its list of incredible applications as new targeting ligands are discovered, specialised nanoparticles are developed, and elegant conjugation procedures are discovered [5, 6].

Conclusions

In summary, recent developments in the surface chemistry of nanoparticles have produced polymer-encapsulated probes that are highly luminous and stable in challenging biological environments. The issues with the ligand exchange-based QD solublization method's short shelf-life, chemical sensitivity, and decreased quantum yield were resolved by this new generation of water-soluble QDs. Due to their connections to bioaffinity molecules, these particles have opened up new possibilities for the ultrasensitive and multicolor imaging of molecular targets in live cells and animal models.

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