Accepted Manuscript

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PII: S1001-8417(18)30277-8
DOI: https://doi.org/10.1016/j.cclet.2018.07.004
Reference: CCLET 4606

To appear in: *Chinese Chemical Letters*

Please cite this article as: Gao G, Jiang Y-Wen, Sun W, Wu F-Gen, Fluorescent quantum dots for microbial imaging, *Chinese Chemical Letters* (2018), https://doi.org/10.1016/j.cclet.2018.07.004

Review

Fluorescent quantum dots for microbial imaging

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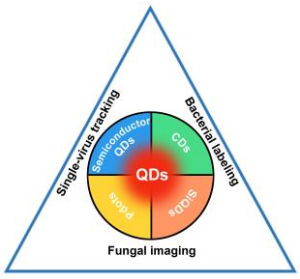
Graphical abstract



QDs (Semiconductor QDs, CDs, SiQDs, and Pdots) are used in imaging microorganisms including viruses, bacteria, and fungi.

ARTICLE INFO

Article history:
Received
Received in revised form
Accepted
Available online

Keywords:
Quantum dots
Single-virus tracking
Bacterial labeling
Fungal imaging
Silicon nanoparticles

ABSTRACT

Quantum dots (QDs), with several unique optical and chemical features, are becoming desirable fluorescent tags for the biological applications that require long-term and highly sensitive imaging. Besides, the conjugation of various functional biomolecules to QDs has enabled wide applications of QDs in biological imaging. This review focuses on the following four types of QDs: semiconductor quantum dots (semiconductor QDs), carbon nanodots (CDs), silicon quantum dots (SiQDs), and polymer dots (Pdots), and summarizes the recent advancements of using these QDs in imaging microorganisms including viruses, bacteria, and fungi. We hope that this review will promote the development of new fluorescent QDs for microbial imaging and extend the applications of QD-based imaging techniques in cell biology and beyond.

1. Introduction

Fluorescence techniques are crucial for life science and medicine and constantly evolving as the novel fluorescent markers and imaging equipment continue to be developed. The utility of fluorescence imaging has generated a tremendous incentive to develop new probes for biological applications. Conventional biological applications employing fluorescence usually include molecular imaging, cell tracking, and biosensing [1−7]. The broad applicability of fluorescence imaging has promoted the development of more versatile fluorescent markers which can be used for both single- and multi-color imaging purposes. Organic fluorophores such as genetically encoded fluorescent proteins and chemically synthesized fluorescent dyes are the most commonly used fluorophores [8−10]. However, there are two significant limitations of these organic fluorophores for further applications. First, they cannot fluoresce continuously for long periods. Second, they are not optimized for multicolor applications, which may be due to their relatively broad emission spectra [11]. Thus, an ideal fluorescent marker for fluorescence imaging should be bright, biocompatible, and stable against photobleaching with narrow emission profiles, and it is highly desirable to develop various other fluoresecent probes to overcome the limitations of conventional organic fluorophores.

Recently, quantum dots (QDs) have been widely used as superior fluorescent materials for imaging and other biomedical applications [12−17]. More specifically, conventional QDs commonly refer to semiconductor QDs which are composed of a semiconductor material