frontiers | Frontiers in Materials

TYPE Editorial
PUBLISHED 28 November 2023
DOI 10.3389/fmats.2023.1328035

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OPEN ACCESS

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RECEIVED 26 October 2023
ACCEPTED 22 November 2023
PUBLISHED 28 November 2023

CITATION
Ganguly S, Das P, Parameswaranpillai J and Maity PP (2023), Editorial: Fluorescent nanomaterials for biomedical applications.
Front. Mater. 10:1328035.
doi: 10.3389/fmats.2023.1328035

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Editorial: Fluorescent nanomaterials for biomedical applications

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KEYWORDS

fluorescence, nanomaterial, biomedical applications, cancer therapy, sensors, diagnostics

Editorial on the Research Topic
Fluorescent nanomaterials for biomedical applications

Introduction

In recent years, fluorescent nanoparticles have proven their utility in a wide range of biomedical backgrounds (Nannuri et al., 2023). These microscopic particles, which can be on the nanometer size, have special luminous features that make them useful in a wide range of medical applications (Sangubotla and Kim, 2023). Because they allow for the clear visualisation of cellular architecture and can act as disease indicators, therefore they find widespread application in imaging and diagnostics (Thakur and Kumar, 2023). Their compact size makes them ideal for focused medication delivery, which boosts therapeutic efficacy while reducing unwanted side effects. Fluorescent nanoparticles have become a prominent area of research in the field of biomedical applications, displaying distinct characteristics that exhibit considerable potential for enhancing diagnostics and therapeutic treatments. These nanomaterials, which are typically nanoscale in size, have outstanding fluorescence properties, allowing for sensitive and real-time imaging at the cellular and molecular levels. Fluorescent nanoparticles are used in a variety of biomedical research applications, including targeted drug administration, bioimaging, and biosensing. Their tunable features, including size, shape, and surface chemistry, allow them to be tailored for specific applications, enabling precise and efficient interactions with biological systems. Fluorescent nanoparticles are also useful for real-time tracking of molecular motion within living organisms and other biological processes (Malode and Shetti, 2023). Because of their versatility and biocompatibility, they show great potential as a tool in the pursuit of better personalised medicine and illness management (Roach, 2023).

Fluorescent nanoparticles have emerged as particularly useful tools in recent years, with the recognition of the use of nanotechnology in biomedical research (Kang and Lee, 2019). This Research Topic of Frontiers in Materials explores recent advances and obstacles related to the application of these materials in biomedicine (Tuerhong et al., 2017; Yao et al., 2019). Applications in bioimaging (Das et al., 2018a; Das et al., 2018b), biosensing (Barrientos et al., 2023; Das et al., 2023), drug delivery (Ganguly et al., 2020; Das et al., 2022; Ganguly and Margel, 2023), and theragnostic are made possible by the unique optical features of fluorescent nanomaterials such as quantum dots, carbon nanotubes, organic dyes, and upconverting nanoparticles (Qian et al., 2023). Topics for this Research Topic range from safety assessments and clinical translatability to novel imaging techniques, biosensing, and drug delivery systems. Fluorescent nanoparticles are expected to play an important role in the future of biomedicine, with the potential to revolutionise illness diagnosis and therapy.

This issue has five articles published. A brief overview of those articles has been discussed in short here:

Quantum dots: an emerging approach for cancer therapy (Devi et al.)

Nanotechnology is without a doubt a scientific method that could lead to new treatments for cancer and give people hope. This is a new tool that can help doctors find and treat a wide range of diseases in new ways. There have already been some good changes because of the finding of quantum dots (QD) nano-transporters. However, the studies on QD nano-transporters are still in their early stages, but they have already been useful to society. The QD changed the way natural images and photos are processed and has shown great promise in bio-imaging, new drug creation, targeted gene delivery, biosensing, and photodynamic therapy (PDT). The point of this study was to show how important QD is for both diagnosing and treating cancer. The goal of this review is to give you a basic understanding of QD, including its benefits, features, uses, and how it works. This review talks about various ways to build QD, including spin-coating, atomic layer desorption, layer-by-layer, ion beam sputtering deposition, hydrothermal, drop-casting, ultrasonic, solvothermal, and electrochemical methods. In addition, the authors went over the different studies that have been done on cytotoxic testing to show that QDs are safe. In a nutshell, this study briefly goes over the ways that QD can be made, the research that is being done now, and how it can be used to treat cancer.

Fluorescence quenching of graphene quantum dots by chloride ions: a potential optical biosensor for cystic fibrosis (Ifrah et al.)

Developing portable assays for monitoring circulatory alterations (Cl^- ion detection) is crucial for detecting cystic fibrosis at the site of care. In this study graphene quantum dots (GQDs) were prepared by carbonising the citric acid at varying temperatures (160°C–200°C) for 30–50 min. The optical properties of the graphene quantum dots (GQDs) were employed to detect chloride ions. Scanning electron microscopy and UV–vis spectrophotometry studies validated the fabrication of amorphous 12–15 nm GQDs with an emission peak at 462 nm when stimulated at 370 nm. The most fluorescent GQDs were synthesised by heating at 160°C for 50 min. The GQD reported fluorescence quenching with the incorporation of Cl^- ions and showed a linear behaviour up to 100 mM (mM) NaCl concentration.

Modifying aluminum phthalocyanine with quantum dots to promote cellular uptake and enhance the efficacy of anticancer photodynamic therapy (Lei et al.)

PDT is an alternate anti-tumor treatment that makes use of photosensitizers (PSs) and targeted photoirradiation. The efficacy of anticancer PDT could be enhanced further using a nanocarrier technology. In this study, the interaction of a complex of aluminium phthalocyanine (AlPcS) and CdSe/CdZnS core-shell structure QDs with tumor cells illuminated with laser light (405 nm) have been studied. The quantum dots act as a carrier and improve the delivery of AlPcS and therefore the QDs–AlPcS complex interacted more effectively with cancer cells than AlPcS alone. The flow cytometry results confirmed that, the combination of QDs–AlPcS complex and laser light (405-nm) is effective in killing cancer cells.

Exploring the sonodynamic effects of bacteriochlorophyll a (Jia et al.)

Sonodynamic therapy (SDT) is a new treatment method based on ultrasound and has shown promise as an alternative to standard medical care for the treatment of cancer. In this study, the ultrasound was used to activate bacteriochlorophyll a (BCA) (BCA was a good sonosensitizer) and generate reactive oxygen generation (ROS). The results revealed that the generated ROS successfully inhibited the growth of the cancer cells.

Capra cartilage-derived peptide delivery via carbon nano-dots for cartilage regeneration (Maity et al.)

Osteoarthritis can be effectively treated with the targeted introduction of site-specific therapeutic drugs. Thus, zwitterionic carbon nano-dots (CDs) with the ability to target the nucleus hold great promise as a medium for efficient peptide delivery to both the cytoplasm and the nucleus. As a nano-agent for optical monitoring of cartilage healing, nucleus-targeting zwitterionic CDs have been synthesised in the current study. Microwave-assisted oxidation was used to add functional groups to zwitterion CDs, which were then conjugated to COL II peptides produced from Capra auricular cartilage using NHS/EDC coupling. Translocation to the nucleus occurs approximately 24 h after peptide-conjugated CDs (PCDs) are taken up by the cytoplasm (30 m). PCDs' multicolor fluorescence (blue, green, and read channel) boosts their optical coding sensitivity, making them a good choice for a versatile, non-invasive tracking device. This study demonstrated that PCDs-based delivery systems induce *ex-vivo* chondrogenic development of ADMSCs better than CDs alone. Researchers saw healing 60 days after injecting pluronic F-127-based PCDs hydrogel into rabbit auricle cartilage lesions. Therefore, PCDs may be a feasible alternative to multimodal therapy medicines.

Editor's perspective

The investigation into the intriguing field of "*Fluorescent Nanomaterials for Biomedical Applications*" reveals notable progress in the advancement of diagnostic and therapeutic approaches. However, while we stand at the cutting edge of this scientific frontier, researchers and practitioners must keep their focus on the road ahead. While the promise of fluorescent nanoparticles in biological applications is evident, there are still several issues that need to be addressed. To enable a smooth transition of these breakthroughs from the laboratory to clinical settings, challenges including long-term biocompatibility, potential toxicity, and scalability of industrial procedures, must be appropriately addressed. Furthermore, the optimization of synthesis procedures and the study of innovative nanomaterial designs to improve targeting specificity and minimize off-target effects constitute essential future research directions. A concerted endeavour will be needed to improve, validate, and advance to ensure that the potential of these nanomaterials is translated into concrete progress in the healthcare field.

Author contributions

SG: Writing–original draft, Writing–review and editing. PD: Writing–original draft, Writing–review and editing. JP: Writing–original draft, Writing–review and editing. PM: Writing–original draft, Writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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