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Application of Optical Nanoparticles in Biomedicine

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Description

During the first decade of this century, a wide range of particles with various compositions and forms and typical diameters between 1 and 200 nm were created. These microscopic objects, commonly referred to as nanoparticles, have a wide range of potential uses in biomedicine, including high-resolution bioimaging and individualised local therapeutics. Different organic and inorganic substances have been employed as different types of nanoparticles in the past. Present-day nanoparticles have the ability to act as intelligent nano-vehicles that can move through the bloodstream and, when appropriately surface-functionalized, locate in certain locations of interest, such as tumours or even individual cells. The so-called optical nanoparticles are those that, when illuminated with optical radiation, produce any form of energy (light, heat, or photoacoustic). Their use for non-invasive imaging and/or treatments has been successful [1].

The original works in this Special Issue of Biomedicines are focused on optical nanoparticles that glow (fluorescent nanoparticles). Concerning the so-called upconversion nanoparticles, there are two works (UCNPs). These nanoparticles are made up of nanocrystals that have been doped with two different types of trivalent lanthanide ions: Yb3+ absorbing ions and Er3+ or Tm3+ emission ions. Near-infrared (NIR) light of around 980 nm excites Yb3+ ions, and the absorbed energy is transferred to the emitting ions to produce various visible luminescence bands through a procedure known as up conversion energy transfer [2]. By converting the NIR-absorbed light into visible fluorescence, UCNPs effectively reduce auto fluorescence and dispersed excitation radiation from biological samples. Additionally, UCNPs don't exhibit photo-blinking, have a high level of photo-bleaching resistance, and, in theory, have relatively low cytotoxicity. As a result, UCNPs have been effectively used for a number of applications, including sensing, drug delivery, auto fluorescence free fluorescence imaging, and other various therapeutic applications.

Baser UCNPs need to have a correct hydrophilic coating, or be appropriately coated with the appropriate molecules to be water dispersible, in order to be biocompatible. Furthermore, UCNPs are typically thought to be non-toxic substances, although the release of fluorides and lanthanides during their dissolution may result in cytotoxicity. In this study, they successfully created inorganic-organic nanohybrids made of cucurbiturils (UCNPs) covered with NaYF4, Yb3+, and Er3+ and examined their cytotoxicity. The visible Er3+ ion upconverted luminescence served as a marker for the internalisation of these nanohybrids in various cell types [3]. These aqueous solution-highly stable nanohybrids were shown to be non-cytotoxic to endothelial cells, but showed a somewhat increased cytotoxicity to HeLa and RAW 264.7 cells.

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Ciprofloxacin, an antibiotic frequently used to treat bacterial infections as well as to prevent prostate or lung cancer, was light-driven medication released by E. Moyano et al. using the blue light of NaYF4; Yb3+, Tm3+ UCNPs (due to Tm3+ ions). Everything was operated with NIR excitation light. The medicine, which cannot be administered directly because it is biologically incompatible, was efficiently delivered as a result of the blue light's emission. In fact, the method used in this study is innovative because it uses a prodrug (oxime ester of ciprofloxacin), in which certain bonds are first broken by the UNCPs' blue light luminescence before the actual ciprofloxacin drug is delivered [4].

Under NIR stimulation, a variety of optical nanoparticles emit light in the near infrared. This is necessary for various biomedical applications, especially in vivo imaging because the NIR is where tissue transparency is at its highest. It is crucial to ensure that nanoparticles are designed logically to minimise heat production because NIR light emission is typically accompanied by heat generation. The review by K. Okubo et al. in this Special Issue looks into the key principles for designing hybrid nanostructures that minimise heat generation by utilising nearby low vibrational centres or molecules with low chemical polarity. Exosomes are a novel substitute for artificial nanoparticles for imaging and medication delivery since they are the smallest extracellular vesicles (50–150 nm). Exosomes have greater accumulation properties than synthetic nanoparticles and could function as natural bio-targeting nanoparticles. These natural nanoparticles' pharmacokinetic characteristics and biodistribution may be precisely (non-invasive) determined in vivo utilising fluorescence imaging. Describe a simple, new method for labelling exosomes (derived from goat's milk) with two different commercial fluorescent dyes using a covalent link between the amine groups in the exosomes and the ester groups of the fluorescent dyes. Fluorescence imaging was obtained using these fluorescent exosomes successfully in in vivo (U 87 and B16F10 cancer cells), in vivo, and ex vivo (mice). They were able to assess these nanoparticles' biodistribution over time in healthy mice using fluorescence imaging [5]. They showed that their fluorescent exosomes were quickly and dose-dependently aggregated around the cell nucleus at the cellular level. Another area of growing interest is nanostructures for multimodal imaging at the molecular level, or those that can be seen using various imaging methods. In a novel method, Fernando Oliveira et al. evaluated the homing and tracking of hematopoietic stem cells in a bone marrow transplant model in young and old mice by using superparamagnetic iron oxide nanoparticles (SPIONs) linked with two different types of fluorophores. These studies are necessary to determine how many transplanted cells have reached the target areas in order to correctly restore bone narrow function.

The linked fluorophores (one absorbs and emits in the NIR range, and the other, Rhodamine-B, absorbs and emits in the visible region) offer the added possibility of using fluorescence imaging techniques, making SPIONs effective contrast agents for magnetic resonance imaging (MRI). As a result, these nanoparticles are great choices for molecular imaging as well as multimodal imaging. Fluorescence imaging was used to conduct thorough in vitro experiments, and Rhodamine-B luminescence was used to observe internalisation in bone marrow mononuclear cells. The internalised SPION nanoparticles in these cells were then measured in relation to the NIR fluorescence and the intrinsic iron oxide magnetic resonance contrast (MRI imaging) [6]. These tests were subsequently used with old and young mice to compare the impact of ageing on the homing and tracking of SPIONs-labeled hematopoietic stem cells following a bone narrow transplant. Additionally, the long-term transplantation of these cells into the bone marrow was monitored using bioluminescence.

Acknowledgement

None.

Conflict of Interest

None.

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