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Theranostic Agents Designed on Nanomaterials

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Introduction

Theranostic nanomedicine is a promising treatment paradigm that is gaining traction. It takes advantage of nanoplatforms tremendous ability to transport cargo and packs both imaging and therapeutic capabilities onto them. The resulting nanosystems, which are capable of diagnostics, drug administration, and therapy response monitoring, are projected to play a crucial role in the nascent era of personalised medicine, and considerable scientific effort has gone into achieving that aim. Many nanoplatforms are already imaging agents, which makes developing such function integrated agents easier. Because of their well-developed surface chemistry, they are simple to load with pharmaceutics and promote as theranostic nanosystems. Iron oxide nanoparticles, quantum dots, carbon nanotubes, gold nanoparticles, and silica nanoparticles have all been extensively studied in imaging and are potential nanoplatforms for nanoparticle based theranostics.

The term "theranostics" was coined to describe continuous clinic attempts to produce more specific, tailored remedies for a variety of ailments, as well as to integrate diagnostic and therapeutic qualities into a single drug. The argument stemmed from the fact that diseases like cancer are extremely heterogeneous, and all present treatments are only effective for a small number of patient subpopulations and at specific stages of disease progression. The hope was that a close relationship between diagnosis and treatment would result in therapeutic procedures that were more tailored to the individual and hence more likely to improve prognoses [1].

Description

The advent of nanotechnology has provided a chance to bring diagnosis and treatment closer together. Nanoparticle (NP) based imaging and therapy have been studied separately, and our understanding of them has progressed to the point where NP based theranostics, or nanoplatforms that can deliver therapeutic and imaging capabilities simultaneously, have emerged. This is a kind of continuation of classical theranostics, but with a focus on "co-delivery." It expands on the preceding paradigm by allowing imaging to be done not just before or after a treatment, but also during it. Many nanomaterials are already imaging agents, and they can easily be "upgraded" to theranostic agents by attaching therapeutic capabilities to them.

Imaging and therapy both necessitate a sufficient buildup of drugs in sick areas, which is one of the driving forces for such a combination. Because many strategies for improving imaging can, at least in theory, be easily transferred to the therapeutic domain and vice versa, this shared targeting requirement pushes the two study fields closer together and, eventually, blurs the line between them. To suits the desired targets, targeting tactics can be adjusted greatly. In the instance of cancer, it's usual to find a biomarker that's abnormally expressed on cancer cells surfaces, then load its corresponding binding vector onto probes/carriers to achieve tumour homing and recognition [2,3].

Nanoparticle based imaging and therapy are both failing to get into clinical trials, and nanoparticle-based theranostics, as progeny of the two, are still in the early phases of development. However, breakthroughs in nanotechnology and the demand for individualised therapy have already pushed nanoparticle-based theranostics to the forefront of study. This review aims to provide a summary of the work done so far in this direction. We'll go over theranostic agents that have potential in the theranostic setting, organised by the category of their fundamental nanomaterial.

However, this essay will not focus on imaging without therapy, and readers are directed to other outstanding reviews on the subject. Instead, we'll concentrate on the development and application of theranostic agents, as well as the surface coating and binding chemistry that could alter cargo movement, delivery, and release. Iron Oxide Nanoparticles (IONPs) are magnetite or hematite nanocrystals. IONPs often have large saturation magnetization (Ms) values at room temperature, despite spin surface disorders and spin canting effect, especially when synthesised using pyrolysis techniques with good crystallinity. IONPs smaller than 20 nm are superparamagnetic, which means they have no magnetism in the absence of an external magnetic field but can become magnetised in the presence of one. The underlying mechanism is that at such a small scale, thermal energy is sufficient to overcome the anisotropy energy of each microscopic magnet (nanoparticle), resulting in random fluctuation of magnetizations and, macroscopically, zero net coercivity and magnetic moment [4,5].

Conclusion

IONPs have become a material of choice in numerous bioapplications, such as contrast probes for magnetic resonance

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imaging, due to their excellent magnetic characteristics, as well as their natural biocompatibility and low cost (MRI). Because of their strong magnetic moments, IONPs can reduce T_2 relaxation time, resulting in signal attenuation on a T_2 or T_{2^*} weighted map. Such signal modifications can be used to report abnormal biological activity when the particles are created with targeted selectivity. The synthesis of IONPs has been extensively studied. IONPs are traditionally produced by co-precipitating Fe (II) and Fe (III) precursors in aqueous solution. To give the particles colloidal suspendability, additives, mainly hydrophilic polymers, are applied during the particle generation process to passivate the nanocrystal surface and prevent aggregation. For this aim, a variety of ligands have been used, including polyvinylpyrrolidone (PVP), dendrimer, polyaniline, and dextran, with dextran and its derivatives being the most investigated. Drug molecules can be easily linked with IONPs with proper coatings. For example, the Zhang group attached an anti-cancer medication called Methotrexate (MTX) to an aminated IONP surface. *In vitro* experiments revealed that the particles gathered in lysosomes after internalisation into cells, where the drug molecules were released due to the low pH and presence of proteases. Hwu et al. reported on a phosphodiester moiety at the (C-2)-OH Position Binding Paclitaxel (PTX) to IONP surfaces.

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Conflict of Interest

The author shows no conflict of interest towards this manuscript.

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