

The Magnetite nanoparticles in theranostic applications

Abstract

Currently, nanotechnologies are widely used in biomedicine, science and industry. It is known that the application of magnetite nanoparticles as nanostructured carriers is one of the promising areas of biomedicine. The formation of polyelectrolyte or nanocomposite microcapsules is widely applied for the coating of magnetic nanoparticles. The microcapsules containing magnetite nanoparticles have good perspectives for theranostics applications, but careful study of their biodistribution and toxicity is necessary to prove the safety of these structures as a diagnostic and therapeutic agents.

Keywords: Magnetite nanoparticles, Theranostics, MRI contrast agents, Targeted drug delivery

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Overview

Recently, more and more research in the field of nanotechnology is aimed to solve the problems of practical medicine. A lot of works is devoted to applications of magnetite nanoparticles in biomedicine, for example, magnetite nanoparticles can be used to enhance contrast and improve diagnostic sensitivity in (MRI).¹⁻³ targeted delivery .⁴⁻⁶ hyperthermia.^{7,8} tissue engineering.⁹ Magnetite is quite a promising material for biomedical applications, in different studies indicates that such nanoparticles have low toxicity, good biocompatibility and sufficient magnitude of effective magnetic characteristics.^{10,11} Low toxicity was also confirmed by *vivo* studies and morphological examination of internal organs of animals after different methods of administration of magnetite nanoparticles .¹²⁻¹⁴

Stability of nanoparticles is the most important characteristic for the biomedical applications. Surface modification of nanoparticles enables them to ensure not only colloidal stability but also biocompatibility. The aggregation and oxidation were observed for inorganic nanoparticles. Coatings of organic and inorganic nature for surface modification of nanoparticles are used to prevent actions like aggregation, sedimentation.^{15,16} Gold modifies the surface in such a way that increases the stability of nanoparticles in aqueous solution .^{17,18} Dextran and its derivatives have a high biocompatibility and are used for stabilization of nanoparticles.^{19,20} Silicon dioxide is often used for stabilization of inorganic nanoparticles because one prevents the aggregation, oxidation of the nanoparticles and as results provides high stability of the colloid.²¹ and reduces toxicity.²² The size and charge of nanoparticles is of great importance for biomedical applications. The larger the particle, the shorter its half-life in plasma, the higher the charge of the nanoparticles, the less time they remain the bloodstream.²³ The nanoparticle absorption from the bloodstream depends on their size.²⁴

The particle chemical composition, its size and shape should be considered for successful use of a magnetic field on the nanoparticles, since these parameters determine the magnetic properties of the nanoparticles. The size of the nanoparticles determines the speed of excretion, and also their distribution in the body.²⁵ based on this the drug delivery to certain organs and tissues is possible. Such type of targeted delivery of drugs allows to reduce the medicine dosage on 20% of the systemic dose and does not affect healthy tissue, thereby the occurrence of side effects can be avoided. In particular, this is an

important during chemotherapy of cancer patients, in which healthy organs and tissues are affected due to undesired biodistribution and high toxicity.²⁶⁻²⁸

At the present time the new trend is developing in medicine which is called theranostics and aims at the same time to the therapy and diagnostics of diseases. Multifunctional nanostructured carriers are developed which find wide application in enzymatic catalysis, controlled release, and directed drug delivery in medicine. Magnetic nanoparticles consistent with this new challenge entirely, as the possibility of their use exists for both diagnosis and treatment.²⁹ Magnetic nanoparticles may be used in theranostics to enhance contrast and improve diagnostic sensitivity of MRI as it was stated above.¹⁻³ as well as for targeted delivery of drugs and implementation of hyperthermia.⁴⁻⁶

Magnetite nanoparticles are used for fabrication of magnetoliposomes or microcapsules.³⁰⁻³⁴ Microencapsulation is the process of surrounding or enveloping one substance within another substance on a very small scale. The capsule size can varied from less than one micron to several hundred microns in size.³⁵ The microcapsules can contain various substances such as nanoparticles, drugs, contrast agents. Microcapsules have small size, large internal volume, large enough surface, have a high effective load of active substances and the flexibility of the physico-chemical properties and are used as micro and sub micro carriers for the development of new effective forms of drugs with prolonged and/or controlled release of the bioactive components (proteins, including enzymes, peptides, hormones, various antigens, DNA, RNA, etc. It can be used as delivery systems for anticancer and antimicrobial drugs, as well as in gene therapy, with the ability to vary the size, structure and physico-chemical properties of the microcapsules .³⁶⁻³⁸ Many research works demonstrate that, as a rule, the capsules are well tolerated by living systems *in vivo* and *in vitro*.^{39,40}

Conclusion

Thus, at present time nanotechnology occupies an important place among the innovative methods of diagnostics and treatment. One of the rapidly developing areas is associated with the creation of effective nanosystems aimed at theranostics - to the therapy and diagnostics of diseases at the same time. The microcapsules containing magnetite nanoparticles have good perspectives for theranostics applications, but careful study of their biodistribution and toxicity is necessary to

prove the safety of these structures as a diagnostics and therapeutic agents.

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Conflict of interest

None.

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