Magnetically Navigated Polysaccharides-based Capsules as Smart Delivery Systems

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Nanomedicine as a dynamically developing part of nanotechnology utilizing novel and effective approaches to eliminate many diagnostic and therapeutic limitations. Complexity of the proposed solutions, as well as potential biomedical applications require interdisciplinary cooperation combining knowledge, techniques and experience in the field of chemistry, materials engineering, biology, physics and medicine. For this purpose solutions based on targeted and controlled delivery and release of biologically active substances play a significant role as a tool in novel medicine.

Obtaining biocompatible systems capable of controllable transport and release of a bioactive substance can significantly contribute to the development of modern therapy and diagnostics. Solutions based on externally stimulated carriers represent a very forward-looking alternative to conventional methods of biologically active substances administration, which are limited by the problems of maintaining the appropriate therapeutic dose, absorption or the occurrence of strong side effects.

Considerable efforts have been dedicated to fabrication and characterization of magnetically controllable polymeric carriers in the form of capsules with oil cores stabilized by modified polymers of natural origin. Researches have been focused on core-shell nanosystems, their magnetically controllable navigation, as well as externally induced release of the transported substance. Two types of carriers were developed: with a negative and with a positive surface charge, containing encapsulated magnetic nanoparticles inside. The therapies which provide carriers that will enable precise and targeted therapeutics delivery contain an innovative and very promising approach, especially in the treatment of neoplastic diseases. The main advantages of this form of treatment include the ability to maintain an appropriate concentration of the active substance at the target site, leading to the death of diseased cells without damaging healthy cells, i.e. without causing additional side effects of the therapy.

The first stage of the research was to obtain and characterize the substances needed to create biopolymer capsules. Due to the dedicated biomedical use of the carrier, syntheses were performed by the modification of a natural origin polymer and reactions leading to the production of magnetic iron oxide nanoparticles. The second stage of the research was the optimization of the capsules preparation procedure and the physicochemical analysis of two types of magnetic carriers obtained. Capsules with a positive surface charge were produced by self-assembly of an amphiphilic chitosan derivative, modified with cationic groups and with alkyl chains grafted on the surface of oil droplets containing dispersed magnetic nanoparticles. The additional application of an anionic chitosan layer on the capsule surface by the LbL technique led to the second type of carrier (with a negative surface charge). Physicochemical properties and stability of the structures obtained at the first and the second stage of the research were investigated using various techniques (light scattering and zeta potential measurements, infrared spectroscopy, X-ray diffraction, Mössbauer spectroscopy, magnetometry and Scanning Transmission Electron Microscopy).

The systems developed were subjected to cellular tests, which constituted the third stage of the experimental part of this work. The research conducted was aimed at verification of the application potential of the capsules in the context of magnetically controlled carriers capable of targeted and controlled transport and release of the encapsulated hydrophobic substance. All assays were performed against a mouse mammary gland tissue derived breast cancer cell line (4T1). The cytotoxicity of the capsules was checked using the XTT test, and the obtained results revealed the appropriate concentration of anionic and cationic capsules, which do not show toxicity to healthy cells. Then, with the use of a constant magnetic field, an experiments relying on the controllable introduction of the capsules, containing the model hydrophobic fluorescent dye, inside the tumour cells were performed. [1,2]

References

[1] J. Odrobińska, E. Gumieniczek-Chłopek, M. Szuwarzyński, A. Radziszewska, S. Fiejdasz, T. Strączek, C. Kapusta, S. Zapotoczny, ACS Appl. Mater. Interfaces, 11 (2019), 10905.
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Figures

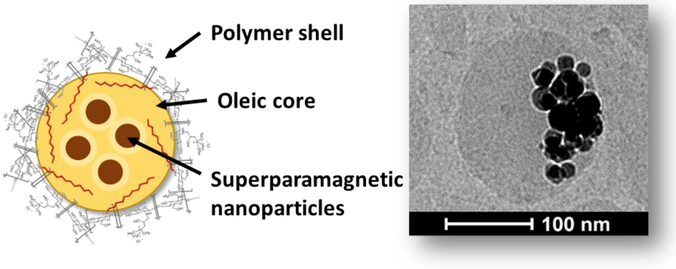

Figure 1. Scheme of the polymer capsule with oleic core and encapsulated magnetic nanoparticles (left picture); cryo-TEM image of magnetic cationic capsules based on oil cores (right picture)[2]