Essentials of Pharmaceutical Product Development for Magnetically Modulated Drug Delivery Systems


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ABSTRACT
There is a renewed focus on developing formulation strategies for the regional drug targeting. Magnetic drug targeting provides an innovative approach that may include two and three dimensional arrays of magnetic drug delivery systems. Applications of magnetic microsphere-based drug delivery include chemotherapy, arthritis, gene, and cell transplantation therapy. This article describes different formulation approaches, routes of administration, and mechanisms of magnetic-based drug targeting. Magnetic materials have to be synthesized before considering the formulation development. Although the preparation evaluation of magnetic drug delivery is comparable with conventional microspheres and nanoparticles, characterization of magnetic properties of the final formulation is very essential for success of this approach. In vivo evaluation studies include tumor targeting in animals, histological evaluation using MRI and course of the magnetic drug delivery system by image mapping using suitable biological markers.

KEYWORDS: Magnetic particles; drug targeting; chemotherapy; bio-separation; microspheres.

Introduction
Drug targeting is the delivery of drugs to receptors or organs or any other specific part of the body to which one wishes to deliver the drug exclusively. Various nonmagnetic microcarriers (nanoparticles, microspheres and microparticles) have been successfully utilized for drug targeting but they show poor site specificity and are rapidly cleared off by the reticuloendothelial system (RES) under normal circumstances. In these cases, magnetism plays an important role. Magnetic particles composed of magnetite and are well tolerated by the body. Magnetic fields are believed to be harmless to biological systems and adaptable to any part of the body. Up to 60% of an injected dose can be deposited and released in a controlled manner in selected “non-reticuloendothelial” organs. Thus, magnetic microcarriers are developed to overcome two major problems encountered in drug targeting namely RES clearance and target site specificity (Jawed-Akhtar et al., 2009).

There are various approaches to targeted drug delivery, which are broadly classified into three categories: The physical or mechanical approach, the biological approach, or the chemical approach.

Magnetism plays an important role in different applications in health care. Magnetic particles composed of magnetite are well tolerated by the body. Magnetic nanoparticles usually exist or can be prepared in the form of a single domain or a super paramagnetic magnetite ($\text{Fe}_3\text{O}_4$), greigite ($\text{Fe}_8\text{S}_8$), maghemite ($\gamma\text{-Fe}_2\text{O}_3$), iron, nickel, etc. Synthetic magnetic materials have many applications in optics, electronic and energy storage. Magnetism has applications in numerous fields like diagnostics, drug targeting, molecular biology, cell isolation, cell purification, hyperthermia, and radioimmunoassay.

Types of Magnetic Drug Delivery Systems (MDDS) and Their Applications
Recently, Zhang et al., 2007 reported magnetic drug delivery by particulate carriers as a very efficient method of delivering a drug to a localized disease site. Very high concentrations of chemotherapeutic or radiological agents can be achieved near the targeted site, such as a tumor, without any toxic effects to normal surrounding tissue or to the body. Magnetic carriers are most commonly manufactured from polymers, since they have a variety of surface functional groups, which can be tailored to specific applications (Zhang et al., 2007).

Different types of magnetic drug delivery systems are:

- Magnetic microspheres, magnetic nanoparticles, magnetic liposomes, magnetic resealed erythrocytes, magnetic emulsion, and magnetic systems in contraceptive delivery.