Review Article **ISSN: 2349 – 7114**

Asian Journal of Research in Pharmaceutical Sciences and Biotechnology

Journal home page: www.ajrpsb.com

A REVIEW ON MAGNETIC DRUG DELIVERY SYSTEM

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ABSTRACT

A number of novel drug delivery systems have emerged encompassing numerous routes of administration, to realize controlled and targeted drug delivery, magnetic magnetic drug delivery system being one amongst them. These magnetic magnetic drug delivery system embrace magnetic microspheres, magnetic liposomes, magnetic nanoparticles, magnetic resealed erythrocytes, magnetic emulsion etc. Magnetic micro/nanoparticles and molecular magnetic labels are used for excellent variety of application in numerous areas of biosciences, targeted drug delivery, imaging and in bio separation technology. These comes can discuss regarding principle of magnetic targeting, mechanism of magnetic targeted drug delivery, edges and downsides of magnetic targeting, magnetic microcarriers and application of magnetism in targeted drug delivery and a few alternative field. Magnetically targeted drug delivery by particulate carriers is AN economical technique of delivering medicine to localized sickness sites like tumours. High concentrations of therapy or imaging agents are often achieved close to the target website with none ototoxic effects to traditional encompassing tissue. Non-targeted applications of magnetic microspheres and nanospheres embrace their use as distinction agents and as drug reservoirs that may be activated by a magnet applied outside the body. Historic and current applications of magnetic drug delivery system are mentioned, further as future directions and issues to be overcome for the economical and useful use of magnetic carriers in clinical observe.

KEYWORDS

Magnetic drug delivery system, Magnetic microspheres and Magnetic nano particles.

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INTRODUCTION

Magnetic nanoparticle-based drug delivery may be a means that during which magnetic particles like iron compound nanoparticles are a part of a delivery vehicle for magnetic drug delivery, thanks to their easiness and ease with magnet-guidance. Magnetic nanoparticles will impart imaging and controlled unleash capabilities to drug delivery materials like micelles, liposomes, and polymers. Magnetic

micro/nanoparticles and molecular magnetic labels are used for excellent variety of application in numerous areas of biosciences, targeted drug delivery, imaging and in bio separation technology. These article can discuss regarding principle of magnetic targeting, mechanism of magnetic targeted drug delivery, edges and disadvantage of magnetic targeting, magnetic microcarriers and application of magnetism in targeted drug delivery and a few alternative field. Magnetically targeted drug delivery by particulate carriers is an economical technique of delivering medicine to localized sickness sites like tumours. High concentrations of therapy or imaging agents are often achieved close to the target website with none ototoxic effects to traditional encompassing tissue. Non-targeted applications of magnetic microspheres and nanospheres embrace their use as distinction agents and as drug reservoirs that may be activated by a magnet applied outside the body. Historic and current applications of magnetic drug delivery system are mentioned, further as future directions and issues to be overcome for the economical and useful use of magnetic carriers in clinical observe. Molecular magnets (single-molecule magnets) are a platform that includes insoluble (toxic) medicine into biocompatible carrier materials, while not adding magnetic iron compound nanoparticles, during which adversely poignant potential facet effects attributed to iron dose, further as low drug loading potency. The drawbacks in typical magnetic drug delivery ways are often overcame by shift from typical iron compound nanoparticles to ones supported molecular magnet, like Fe (salen)-based "anticancer nano-magnet" with evidenced cancer-fighting ability. However, insoluble medicine as well as Fe (salen) even have some inherent drawbacks, like poor water solubility, loss of magnetic activity in solvents, and potential toxicity once accumulated in tissues and organs. As an alternate artificial technique of magnetic drug delivery, a "non-iron oxide"- based sensible delivery platform has been terribly recently developed by self-assembly of the Fe(salen) medicine into nano-cargoes encapsulated by a sensible chemical compound, exhibiting bio-safe multifunctional magnetic capabilities, as well as magnetic resonance imaging, magnetic field- and pH-responsive energy-releasing physiological state effects, and controlled unleash. Magnetic drug delivery system works on the delivery of magnetic nanoparticles loaded with drug to the growth website beneath the influence of external field. However, development of this delivery system mandates that the nanoparticles behave magnetic solely beneath the influence of external field and are rendered inactive once the external field is removed. Luckily, such magnetic properties are sometimes nonheritable by terribly little nanoparticles among the scale vary of but ten nm, thanks to the presence of single domain state. Materials has been drawn for simplicity. Proprietary from reference (Mody *et al.* 2013). Ferrite oxide - magnetite (Fe3O4) is that the present minerals on earth that is wide utilized in the shape of super paramagnetic nanoparticles for numerous biological applications, like magnetic resonance imaging, magnetic separation, and magnetic drug delivery. However, the utilization of magnetic nanoparticles in vivo desires heap of surface modification therefore on defend them from RES and increase the steadiness of molecule in vivo. Organic ligands like polythene glycol, dextran, aminosilanes are usually accustomed stabilize the magnetic nanoparticles. In this review we'll focus totally on the nanoparticles that are used for drug and cistron delivery. Additionally, applications and results of *in vitro*, animal and clinical experiments are mentioned.

Composition of Magnetic nanoparticles

Magnetic core material

There are several magnetic materials on the market with a large vary of magnetic properties. However, several of those materials, like metal and Cr, are extremely ototoxic and unlikely to be used as medicine agents in vivo while not a non-toxic, protecting coating with high mechanical strength. Iron oxide-based materials like magnetic iron-ore and magnetite, however, are comparatively safe and are presently in use within the clinic as magnetic resonance imaging distinction agents. The subsequent are some magnetic materials appropriate to be used in medicine applications.

Magnetite Fe_3O_4

Magnetite may be a common mineral that exhibits ferro (ferri) magnetic properties. The structure of magnetic iron-ore belongs to the mineral cluster that features a formula of AB_2O_4. Its magnetic attraction structures arise from alternating lattices of Fe (II) and Fe (III). This offers it a really sturdy magnetization compared to present magnetism compounds like the ferrihydrite core of the protein macromolecule.

Maghemite γ-Fe_2O_3

Maghemite, a topotactic chemical reaction product of magnetic iron-ore, has the identical lattice structure as magnetic iron-ore however all iron atoms are in Fe (III) number. It are often thermally remodeled to alternative kinds of iron (III) oxides like heamitite that is magnetism. The sturdy magnetization of maghemite (about one hundred times stronger than iron ore and ferrihydrite), that is on the order of magnetic iron-ore, is thanks to lattice vacancies that produce to unpaid lepton spins among the structure. Maghemite is one amongst the foremost appropriate materials for the core of magnetic nanoparticles as a result of it's least probably to cause any peril. Iron (III) ions are wide found in soma therefore natural process of metal mustn't cause important side-effects. As a result, maghemite may be a fashionable alternative for creating magetic nanoparticles, particularly for medicine applications.

Iron-based metal oxides

There are several iron-based metal oxides that exhibit sturdy magnetic properties and may be used as magnetic cores for building the magnetic nanoparticles.

Iron alloys

Although iron metal itself may be a sensible material for magnetic applications, it's rarely used as core material for the synthesis of magnetic nanoparticles unless they are coated with an inert, protecting coating. Iron is exceptionally liable to corrosion in presence of water, ie, rusting. Robust, non-porous coatings are essential for nanoparticles with iron metal cores. Also, functionalizing the iron surface isn't simple. Therefore, iron alloys, like FePt and FeAu, are additional fashionable as core materials for magnetic nanoparticles.

Other materials

Other attainable core materials for magnetic nanoparticles embrace lanthanoid metal alloys and transition metal clusters. The utilization of those materials for magnetic nanoparticle core synthesis continues to be rare thanks to their potential ototoxic effects on the soma.

Coating materials

Nanoparticles are additional reactive than bulk materials thanks to their high surface to volume quantitative relation. As a result, these core nanomaterials must be protected against corrosion. This coating conjointly prevents the natural process of probably ototoxic elements into the body throughout *in vivo* applications.

Natural polymers

Coating magnetic nanoparticles with natural polymers like carbohydrates and proteins is common. Example, dextran-coated magnetic nanoparticles are utilized in several medicine applications like cancer treatment and magnetic resonance imaging , and that they are commercially on the market. Functionalization is additionally attainable by creating use of the chemical group teams on the saccharide skeletons so as to diversify the surface properties, dextran has conjointly been used as a mix with alternative polymers (including chitosan, poly-L-latic acid, and silica) to create merging coatings for magnetic nanoparticles.

Synthetic organic polymers

Since several natural polymers lack mechanical strength whereas others, like polyose, are too rigid to be manipulated to coat nanoparticles, artificial polymers might offer an answer to the present drawback. Artificial polymers like poly (ethyleneglycol) (PEG) polyvinyl alcohol (PVA) and poly-L-lactic acid (PLA) are some examples or coatings for magnetic nanoparticles. The selection of artificial chemical compound coating depends on the specified surface properties for specific applications.

Silica is an amorphous material with high mechanical strength. It carries negative charges at pH <3 because of the silanol groups (–Si–OH) on the surface. In order to alter the surface chemistry of silica, silylation can be carried out with use of

functional alkoxysilane, such as aminopropyltriethoxysilane, or ATPES (X = NH_2).

Gold

Gold is one of the most commonly used materials for bioscience interfaces. It is not only very stable but also easily functionalized via thiol linkers (–SH). Figure shows how gold-coated magnetic nanoparticles can be functionalized with thiol linkers. It is well-known that thiols, and many other sulphur compounds, have high affinity to the gold surface.

Gold-coated magnetic nanoparticles were first reported in 2001 when Lin *et al* (2001) prepared so-called "Fe@Au" (gold-coated iron) nanoparticles (18–80 nm in diameter) via the reverse micelle mechanism. The iron metal nanoparticles were prepared inside the micelle followed by gold coating. To avoid aggregation, 1-dodecanethiol ($C_{12}H_{25}SH$) was bound to the gold surface of the nanoparticles through a self-assembly mechanism. These gold-coated nanoparticles can be functionalized for binding biomolecules by using thiol linkers with a functional group (such as amine) at the other end of the molecules.

Organic linkers

Without surface modification, biomolecules may not bind to the magnetic nanoparticles. Even if they do, the interaction between biomolecules and the surface of nanoparticles can be very weak, resulting in the instant release of these molecules during the delivery with little control. As a result, surface modification is necessary to create strong interactions to enhance the binding process of biomolecules and also to control the release mechanism.

Modification through organic linkers is commonly used, as organic linkers provide a wide range of surface properties to suit various biomolecules in many conditions.

Design and synthesis of magnetic nanoparticles

In biotechnology, the essential features of nanoparticles are their nano-scale dimensions, their magnetic properties and their capability of carrying active biomolecules for specific tasks. In order to be easily localized/targeted inside the human body, the nano-scale dimensions of particles allow them not only to pass through the narrowest blood vessels but also penetrate through cell membranes when necessary If these particles are ferromagnetic/super paramagnetic, they can be manipulated by an external magnetic field, which can drive them to the target organs for gene or drug delivery The active biomolecules bound to the surface of these nanoparticles can then be released. As a result, a functional magnetic nanoparticle consists of a number of components; the magnetic core, the protective coating, and the surface functionality. For biomedical applications, magnetic nanoparticles should also have active biomolecules according to the specific applications.

Synthesis of magnetic nanoparticles

Many different synthetic routes of magnetic nanoparticle synthesis have been reported. Some of them are one-step, while others are multi-step procedures. They all have advantages and disadvantages, and none of them provides a universal solution for all types of magnetic nanoparticles. One has to consider whether the chosen route is suitable for preparing a specific magnetic nanoparticles in a given environment with available instruments and facilities. Most of these procedures involve simple, basic inorganic chemistry, particularly iron chemistry. The following are several commonly used methods.

Wet precipitation and co-precipitation

Wet precipitation is one of the oldest methods for preparation of magnetic nanoparticles. By carefully controlling the pH of a iron salt solution, iron oxide forms as a fine suspension with particle sizes as small as 5 nm. This simple method for making magnetic nanoparticles does not required any specialized facilities. Indeed, precipitation of the iron oxides is a simple, classic chemical testing method (qualitative analysis) for identifying the existence of iron (II) or iron(III) ions in an aqueous solution/.

Mixed oxide particles (eg, magnetite Fe_3O_4, ferrites including $CoFe_2O_4$ $NiFe_2O_4$) can also be prepared by co-precipitation with a stoichiometric solution of the two metal ions. For example, magnetite can be prepared by adding base to a mixture of Fe^{2+} and Fe^{3+} solution following the equation:

$$Fe2+(aq.)+Fe3+(aq.)+8OH−(aq.)→Fe3O4(s)+4H2O(I)$$

However, preparation of mixed oxides via the co-precipitation method is less straight forward, as these metals precipitate at different pH values.

Reverse micelle mechanism

The formation of micelles is a classic phenomenon of surfactant chemistry Surfactants are molecules with a hydrophilic head and a long, hydrophobic tail The formation of micelles occurs when the concentration of surfactant molecules reaches a certain level, or critical micelle concentration 1 (CMC1, while CMC2 is the concentration triggering the self-assembly of liquid crystals which is not discussed here). Normal micelles form in an aqueous medium (such as using detergents in cleaning processes) but reverse micelles form in an oily medium (eg, hexane). The center of these reverse micelles is hydrophilic and stores the inorganic components of the reaction mixture. For the synthesis of iron oxide-based magnetic nanoparticles, inorganic precursors such as iron (III) chloride are dissolved in an aqueous medium and added to the oily reaction mixture with the surfactants. This is followed by the addition of pH regulators (eg, ammonia or NaOH) and inorganic coating materials (eg, silica or gold).

Chemical vapor condensation (CVC)

When some volatile metal compounds are heated in a inert gas atmosphere, these compounds decompose and form metal nanoparticles. This method is termed chemical vapor condensation (CVC). Metallic iron nanoparticles prepared using CVC mechanism have been reported. In this work, iron carbonyl, Fe $(CO)_5$, was used as iron precursor and the particle size averaged to 5–13 nm.

Thermal decomposition and reduction

When metal oxy-salts (such as nitrates, carbonates and acetates) are heated to a certain temperature, they decompose to form metal oxides. For example, iron (III) nitrate decomposes to iron (III) oxide according to the following equation:

$4Fe(NO_3)_3(s) \rightarrow 2Fe_2O_3(s) + 12NO_2(g) + 3O_2(g)$

These metal oxide nanoparticles can be further reduced to metal by heating the oxides to a certain temperature under a reducing gas, usually hydrogen (H_2) or carbon monoxide (CO), following the equations:

$MO + H_2 \rightarrow M + H_2O$

$MO + CO \rightarrow M + CO_2$

Liquid phase reduction

Liquid phase reduction usually is applied to reduce magnetic or non-magnetic metal oxides to magnetic metal or metal alloy, with the use of powerful reducing agents, such as $NaBH_4$ and $LiAlH_4$. $NaBH_4$ is a particularly popular reducing agent in this area because it is soluble in both methanol and water.

Applications

Site-specific Drug-delivery System

Magnetic Delivery of Cancer Treatment Chemotherapy is a balancing act between efficacy and toxicity and a number of strategies have been developed that aim to resolve this dilemma. Chemotherapy via a regional artery administers a more concentrated dose of the active agent directly into the tumor while limiting systemic drug concentration. The site-specific delivery of anti-tumor agents tries to reduce the negative side effects of systemic chemotherapy (intravenous application), and may be able to overcome the multiple drug-resistant phenotype.

One type of regional chemotherapy, drug-carrying MPs, may also achieve wide dispersion throughout the tumor through the action of magnetic force on the particles. Regional drug delivery, however, will not be effective at treating distant sites of tumor metastases unless the drug is targeted to each known site. Magnetic drug targeting as a drug-delivery system can be used in loco-regional cancer treatment. Loco-regional and intra-arterial chemotherapy can avoid the first-pass effect and permit a higher local concentration of the chemotherapeutic agent in the tumor. Initiated the investigation of magnetic guidance applied to local drug-targeting chemotherapy of esophageal cancer by oral administration, a new route in the field of magnetic guidance.

Magnetic Delivery to the Lungs

Drug targeting to the lungs, as well as carriers and methods for such targeting, have been already well reviewed in the literature. Numerous attempts have been made to use immunotoxins for targeted treatment of malignant lung diseases. With a properly designed magnetic targeting system, the drug particles would be guided to the cancerous

tissue by an appropriate magnetic field. The magnetic field would also have to be strong enough to overcome mucociliary clearance. A numerical model of aerosol particle motion in a magnetic field was also developed to predict the targeting pattern of aerosol particles. The results of this model study show promise in the application of magnetic targeting for aerosolized delivery of chemotherapeutic agents.

Topical Magnetic Delivery

The increase in drug accumulation upon stratum corneum and epidermis plus dermis clearly demonstrates the influence of MNPs in topical application. Several interesting biological applications have taken the advantage of the development of an active nanoemulsion formulation used in controlled drug delivery with higher target properties. Entrapment of photosensitizer drugs into magnetic nanocarriers can result in an excellent nano drug-delivery system acting synergically by photodynamic therapy.

Markers for Cellular MRI

The field of molecular imaging has recently gained widespread interest across a spectrum of disciplines. MRI is one of the most powerful noninvasive imaging modalities utilized in clinical medicine today. The applications of MRI have steadily increased over the past decade. MRI offers the advantage of high spatial resolution of contrast differences between tissues.

The ability of MNPs to enhance proton relaxation of specific tissues and serve as MRI contrast agents is one of the most promising applications of nanomedicine. Due to their unique physical properties and ability to function at the cellular and molecular level of biological interaction, MNPs are being actively investigated as the next generation of MRI contrast agents. During recent years, there has been an increase in interest regarding the use of MNPs as contrast agents, such as dextran magnetite in MRI. Although particles of iron oxide have been used as magnetic contrast agents for over 45 years, refinements in the synthesis and coating of MNPs, especially in the last decade, has led to their employment in an abundance of novel biological applications. These applications include blood pooling, tissue- and cell-specific contrast agents for MRI, cell tracking and biomolecular detection. In addition to the targeted imaging applications reviewed in the previous sections, exciting novel molecular imaging applications of MNPs, such as in the imaging of cell migration/trafficking, apoptosis detection and imaging of enzyme activities, are currently being investigated.

Magnetic Fluid Hyperthermia

Hyperthermia is a promising approach to cancer therapy, and various methods inducing hyperthermia, such as the use of hot water, capacitive heating and induction heating, among others, have been employed. Some researchers have proposed the concept of 'intracellular' hyperthermia and have developed submicron MPs for inducing hyperthermia.

The inevitable technical problem with hyperthermia is the difficult issue of heating only the local tumor region to the intended temperature without damaging the surrounding healthy tissue. MNPs have been used for hyperthermia treatment in an attempt to overcome this obstacle. Magnetic fluid hyperthermia involves the introduction of ferromagnetic or super paramagnetic particles into the tumor tissue; under the alternating magnetic field, the MPs can generate heat by hysteresis loss. The particles transform the energy of the alternating magnetic field into heat by several physical mechanisms, and transformation efficiency strongly depends on the frequency of the external field as well as the nature of the particles, including magnetism and surface modification. Owing to the strong magnetic property and low toxicity, the application of Fe_3O_4 in biotechnology and medicine has attracted significant attention.

Therapeutic strategy using magnetic particles

Functionalized magnetic nanoparticles accumulate in the tumor tissues via the DDS. Magnetic nanoparticles can be used as a tool for cancer diagnosis by MRI. Hyperthermia can then be induced by alternating magnetic field exposure, thus, magnetic nanoparticles can be used for cancer therapy at the same time as diagnosis.

Magnetic Particle-based Immunoassays

The specific analytical determination of low concentrations of biological molecules such as proteins and nucleic acids requires at least one

molecular recognition event. To facilitate the detection of the binding event, the reaction can be labeled with a signal-generating moiety. In recent years, the increasing utilization of MPs functionalized with chemically functional groups or biological molecules in clinical practice paves the way for the direct analysis of clinical samples with extremely high analyte concentrations without dilution, therefore avoiding the exterior matrix effect. By applying a magnet, MPs with super paramagnetism show good dispersion and congregation behavior, enabling fast mass transfer of proteins and quick separation of bound and free immunocomplex. In addition, application of MPs helps to eliminate nonspecific binding, retain better activity of immobilized biomolecules and stabilize the binding between solid-phase and proteins. Other advantages include more specific surface area obtained for the binding of larger amounts of biomolecules, lower mass-transfer resistance and selective separation of the immobilized biomolecules from a reaction mixture by simple application of a magnetic field and/or sensitive detection based on variation of the magnetic permeability of super paramagnetic particles.

Very sensitive superconducting quantum interference device magnetometers have been tested to measure antigen–antibody interactions. In this system, antibodies are labeled with MNPs and the antibody–antigen reaction is measured by detecting the magnetic field from the MNPs present in the complex. At present, 4×10^6 magnetic markers (diameter = 50 nm), corresponding to 520 pg of magnetic material, can be detected.

Tissue Engineering using MNPs

Tissue engineering holds great promise as a means of resolving various issues surrounding organ transplantation. Since cells labeled with MNPs can be manipulated using magnets, a novel tissue engineering methodology using magnetic force and functionalized MNPs, referred to as magnetic force-based tissue engineering, was proposed by Ito *et al*. Researchers in France have investigated a new direction for 3D cell patterning that could find applications in tissue engineering. Rather than relying on substrate chemical or physical modifications, they perform the cell patterning using external magnetic forces with which they control the organization of cells on a substrate and create a 3D multicellular assembly. These nanomagnets could challenge the use of commercial NPs, which are covered with a layer of polymers and thus require the use of a transfecting agent to enter cells. This labeling method had been tested on a large number of cell types from different species: immune cells, malignant cells and muscle cells, among others. The labeling did not affect cell proliferation, or the therapeutic and functional properties of the tested cell types, either *in vitro* or *in vivo*. These magnetic cellular markers are therefore fully biocompatible. This technology is presently being applied to various cell types such as human mesenchymal stem cells and retinal pigment epithelial cells. These results suggest that magnetic force-based tissue engineering is a promising approach for tissue engineering.

Detoxification of Biological Fluid

In an attempt to isolate living cells from biological fluids containing toxic substances using cell surface antigens for cell–NP binding, magnetic beads were coated with antibodies, specifically in nearly all these cases with epithelial-specific antigens (clone VU-1D9). The size of these particles varied from 50 nm to a few microns, the matrix material was mostly silica and in some cases polystyrene. During incubation of a blood sample with beads coated with an epithelial-specific antibody, the beads bind to the epithelial cells. The rosetted cells can then be purified by washing on a magnet rack. In all cases, the purity, recovery rate and condition of the isolated tumor cells depends on the number of washing steps, the composition of used buffers and the specification of the beads.

Magnetic Cell Separation

The processes of isolation and separation of specific molecules are used in almost all areas of biosciences and biotechnology, and are the most documented and currently the most useful application of MPs. Several review papers can be found in the literature describing various aspects of magnetic cell separation. These papers are usually focused on specific topics, such as the application of magnetic separation techniques in microbiology, immunomagnetic separation of cells using

Dynabeads®, cell separation with magnetic colloidal labels or the application of carbohydrate-coated magnetic beads for the isolation of cells that specifically express cell surface carbohydrate-binding molecules.

Bioseparation process via gold-coated magnetite nanoparticles

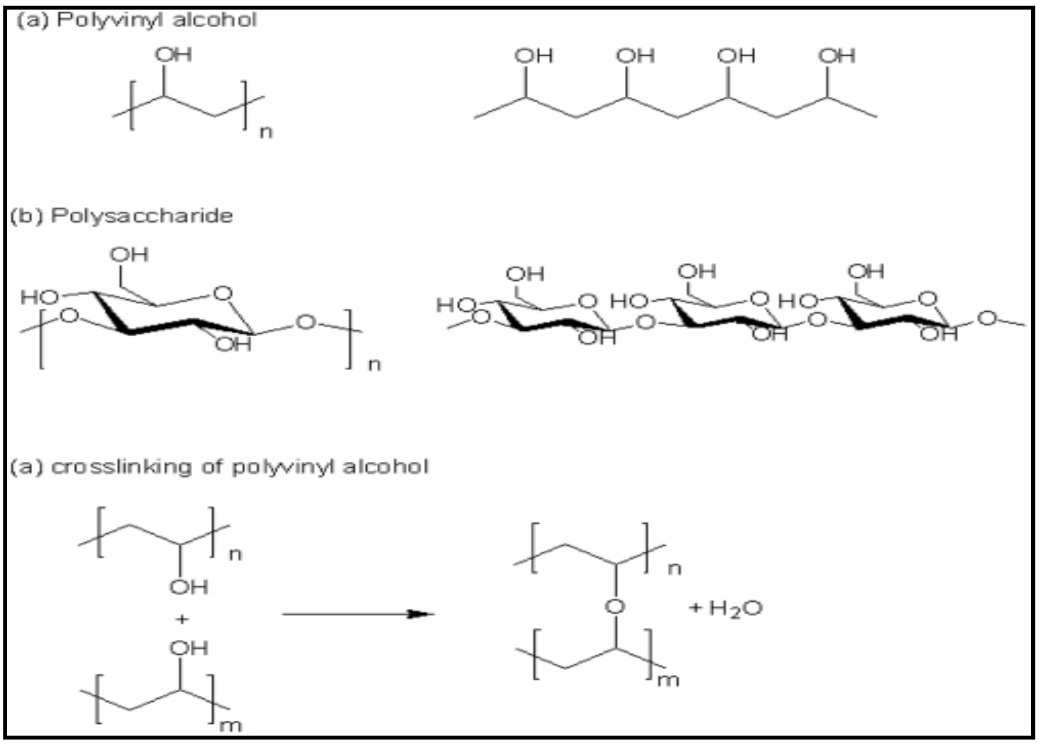
Magnetic separation of cells has several advantages in comparison with other techniques used for the same purpose. It permits the target cells to be isolated directly from crude samples such as blood, bone marrow, tissue homogenates, stool, cultivation media, food, water and soil, among others.

In the first step, the suspension containing the cell of interest is mixed with magnetic labels. Interaction of the target cells and the labels occurs during the incubation step (usually not longer than 30–60 min in laboratory scale). Then the magnetic complex formed is separated using an appropriate magnetic separator and the supernatant is discarded or used for another application. In the second step, the magnetic complex is washed several times to remove unwanted contaminants.

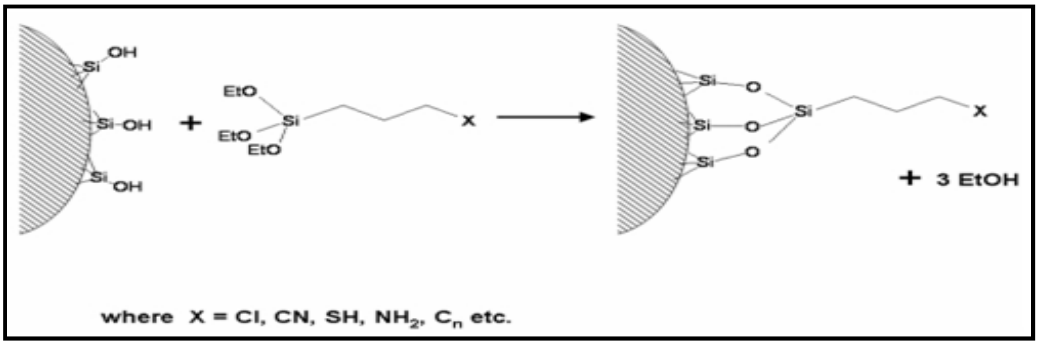
In this form the selected cells with attached magnetic labels can be directly used, for example, for cultivation experiments. Alternatively, the cells can be disrupted and the cell content analyzed using a variety of methods (e.g., chromatography, electrophoresis and PCR). Finally, in the third step, for selected applications, the magnetic label has to be removed from the separated cells.

Gene Delivery

Magnetofection is a new method to enhance the introduction of gene vectors into cells. The idea is to associate MNPs with DNA and either its transfection reagent or its virus vector. A gene-delivery system combining magnetic cationic liposomes and magnetic induction was found to achieve enhanced transfection efficiency in human osteosarcoma cells.



The structure of polyvinyl acetate (a) that is compared with a carbohydrate (b) as each materials have galore chemical group teams on surface. The cross linking reaction is shown in (c) Silica



Silylation of a silica surface using triethoxysilane

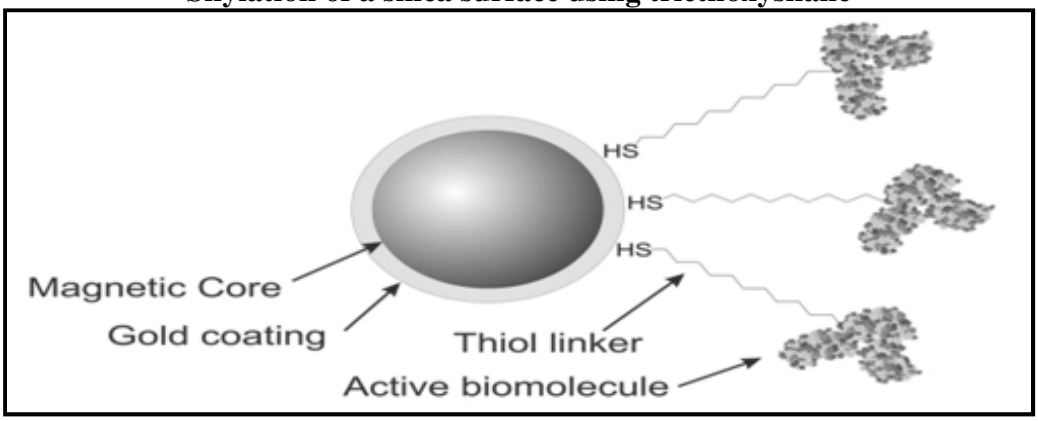
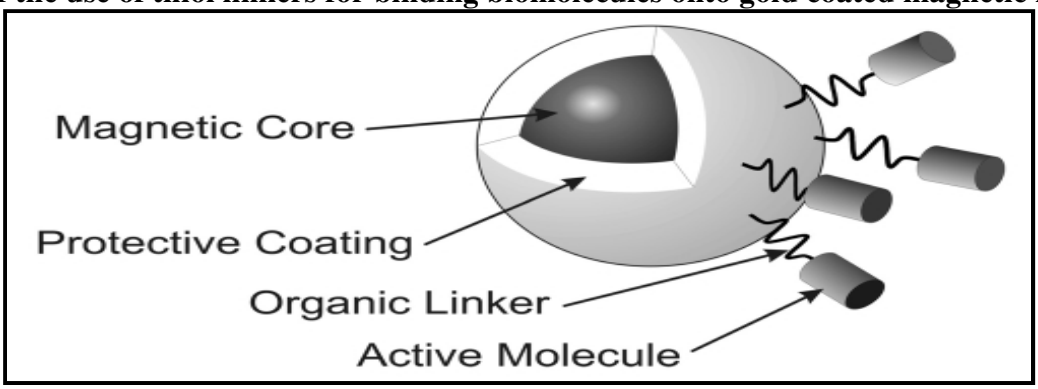


Illustration of the use of thiol linkers for binding biomolecules onto gold coated magnetic nanoparticles



A typical design of a magnetic nanoparticle for biotechnology

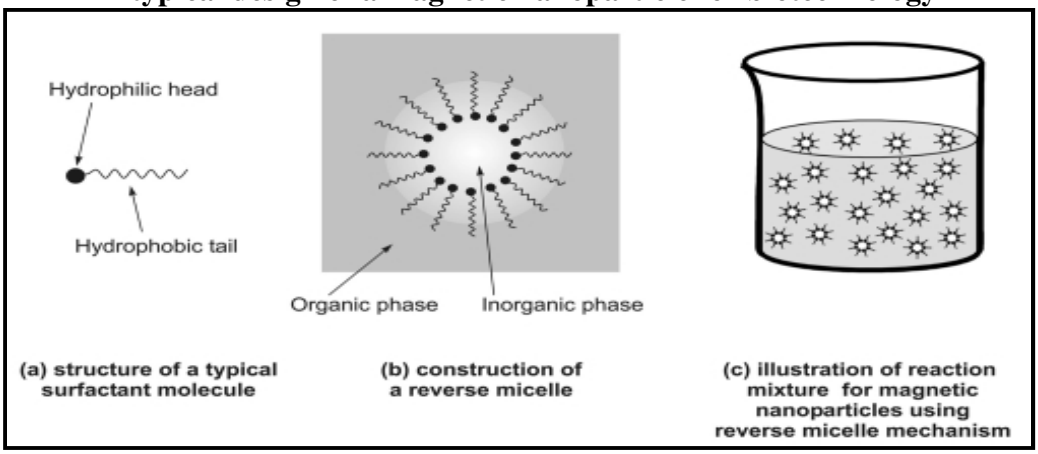
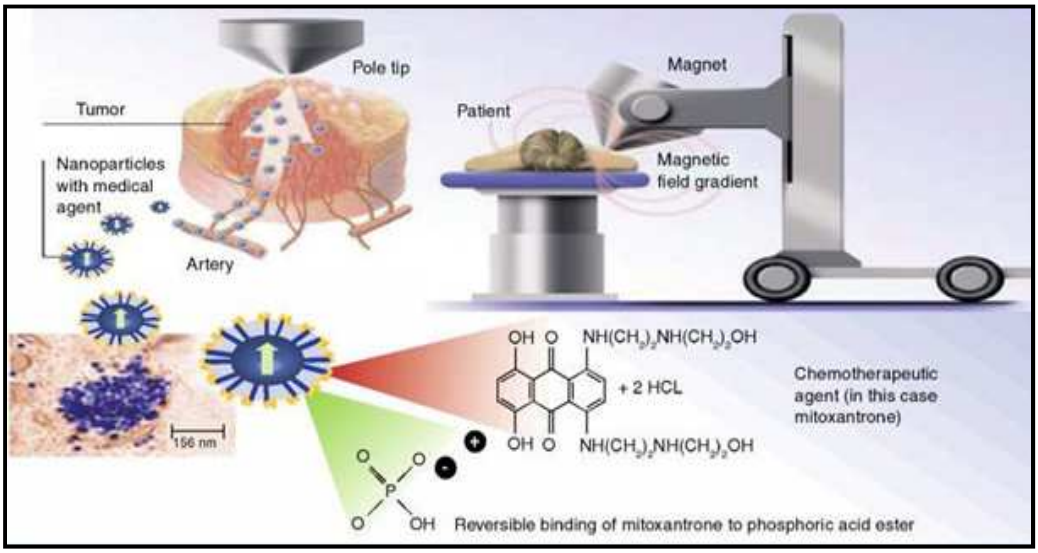
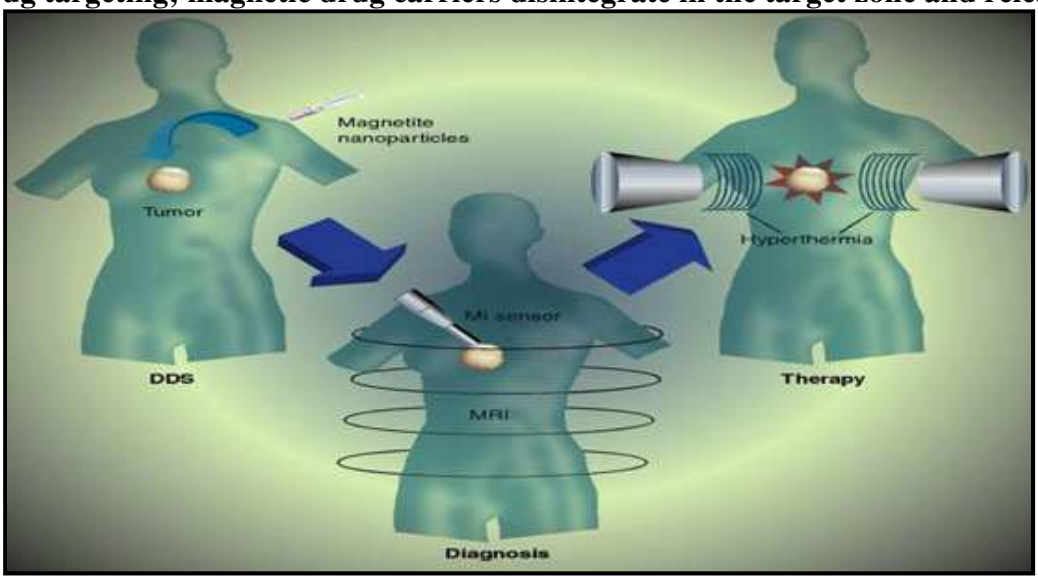


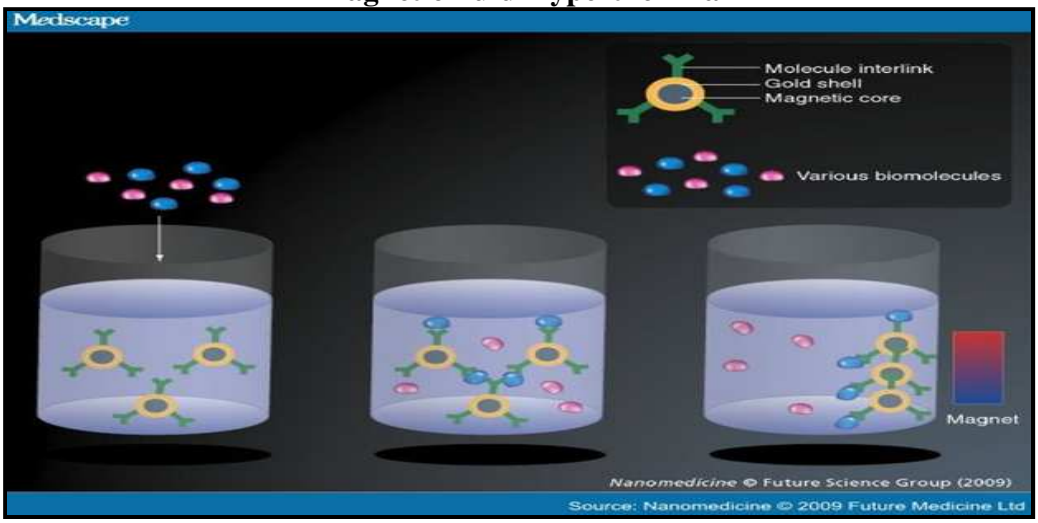
Illustration explaining the use of the reverse micelle mechanism in synthesizing magnetic nanoparticles



Magnetic drug targeting; magnetic drug carriers disintegrate in the target zone and release the drug



Magnetic fluid Hyperthermia



CONCLUSION

Though progress in clinical applications of magnetically targeted carriers has been slow since first introduced in the 1970s, the potential for this technique remains great. Rapid developments in particle synthesis have enabled the use of new materials for more efficient capture and targeting and novel strategies are being developed for applying magnetic fields which could lead to treatments for diseases such as cystic fibrosis and localized cancerous tumors. Though clinical trials are few, the results have been promising. While magnetic targeting is not likely to be effective in all situations, with further development it should provide another tool for the effective treatment of a variety of diseases.

ACKNOWLEDGEMENT

The authors are sincerely thanks to the Department of Pharmaceutics, Santhiram College of Pharmacy, Nandyal, Kurnool District, Andhra Pradesh, India for providing the facilities to complete this review work.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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Please cite this article in press as: Pavankumar K *et al.* A review on magnetic drug delivery system, *Asian Journal of Research in Pharmaceutical Sciences and Biotechnology,* 6(3), 2018, 64-75.