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A REVIEW ON MAGNETIC NANO PARTICLES

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ABSTRACT

This review focuses on the synthesis, properties, specifications, design characterization, and application of magnetic nanoparticles, as well as the safety and biocompatibility of the nano structured systems. A nanoparticle can be defined as a material with three external dimensions of equal nanoscale dimensions .The major benefit of using nanoparticles is that, due to their size, they can be accurately manoeuvred and targeted to a specific biological entity or marker and interact on a cellular (10–100 nm), sub cellular (20–250 nm), protein (3–50 nm), or genetic scale (10–100 nm) .By functionalizing the polymer or metal coating it is possible to attach, for example, cytotoxic drugs for targeted chemotherapy or therapeutic DNA to correct a genetic defect. Their unique, electronic, optical, and magnet properties coupled with their specific dimensions have furthered their attractiveness in this field . Furthermore, nanoparticles can be customized for a specific biological purpose such as cell isolation, drug delivery, diagnostics (magnetic resonance imaging MRI), cellular imaging, and hyperthermia. Examples of nanoparticles include quantum dots and magnetic nanoparticles (MNPs). Magnetic nanoparticles will be the main focus of this paper.

Key words: Magnetic nanoparticles, Ferrite, Hyperthermia.

INTRODUCTION

Magnetic nano particles are of great interest for researchers from a wide range of disciplines, including magnetic fluids in biotechnology/biomedicine, magnetic resonance imaging,5data storage and environmental remediation. While a number of suitable methods have been developed for the synthesis of magnetic nano particles of various different compositions, successful application of such magnetic nano particles in the areas listed above is highly dependent on the stability of the particles under a range of different conditions. In most of the envisaged applications, the particles perform best when the size of the nanoparticles is below a critical value, which is dependent on the material but is typically around 10–20 nm .Such small particles tend to form agglomerates to reduce the energy associated with the high surface area to volume ratio of the nano sized particles. Moreover, naked metallic nanoparticles are chemically highly active, and are easily oxidized in air, resulting generally in loss of magnetic mad disposability. For many applications it is thus crucial to develop protection strategies to chemically stabilize the naked magnetic nanoparticles against degradation during or after the synthesis. These strategies comprise grafting of or coating with organic species, including surfactants or polymers, or coating with an inorganic layer, such as silica or carbon. It is noteworthy that in many cases the protecting shells not only stabilize the nanoparticles, but can also be used for further functionalization, for instance with other nanoparticles or various lagans, depending on the desired application [1].

Functionalized nanoparticles are very promising for applications in catalysis, bio labeling, and bioseparation. Especially in liquid-phase catalytic reactions, such small and magnetically separable particles may be useful as quasi homogeneous systems that combine

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the advantages of high dispersion, high reactivity, and easy separation. In the following, after briefly addressing the magnetic phenomena specific for nanoparticles, we focus mainly on recent developments in the synthesis of magnetic nanoparticles, and various strategies for the protection of the particles against oxidation and acid erosion. Further functionalization and application of such magnetic nanoparticles in catalysis and bio separation will be discussed in brief. Readers who are interested in a more detailed treatment of the physical properties and behavior of these magnetic nanoparticles, or biomedical and biotechnology applications, are referred to specific applications [2].

Properties of Magnetic Nanoparticles

The physical and chemical properties of magnetic nanoparticles largely depend on the synthesis method and chemical structure. In most cases, the particles range from 1 to 100 nm in size and may display super par magnetism.

Surface Properties

Surface Charge

Veisehet al suggested that charged MNPs will cause proteins to absorb the MNPs, which will be recognized by the RES and then removed from circulation (Duran, et al 2008). Specifically, positive charged MNPs also bind to non-specific cells, and strong negative charged MNPs result in increased liver up take. This produces an electric potential distribution, which proves the basis of electrophoresis, the motion of dispersed colloids relative to a fluid upon application of an external electric field. Duran et al give examples on how this is useful for preparation and use of nanoparticles, such as coating and drug loading [3].

Size-dependent magnetic properties

Magnetic nanoparticles exhibit a variety of unique magnetic phenomena that a drastically different from those of their bulk counterparts. The fundamental magnetic properties such as coactivity (Hc) and susceptibility are dependent to variations in their size, shape, and composition.

When the size of nanoparticles is below a critical value (Dc), each nanoparticle becomes a single magnetic domain and shows super paramagnetic behavior when the temperature is above the blocking temperature (Tb). Such individual nanoparticles have a large constant magnetic moment and behave like a giant paramagnetic atom with a fast response to applied magnetic fields with negligible remanence (residual magnetism) and coactivity (the field required to bring the magnetization to zero). These features make super paramagnetic nanoparticles very attractive for MR contrast agents.

Advantages of Magnetic Nanoparticles

- Besides detection, the additional advantage of magnetic particles lies in the inherent ability to respond to a static or ac magnetic field: manipulation by magnetic field gradient (magnetic carriers, separation), additional local magnetic field (MRI) and energy transfer.
- The advantage of magnetic hyperthermia is that it allows the heating to be restricted to the tumor area. Moreover, the use of sub domain magnetic particles (nanometer-sized) is preferred instead multi domain (micron-sized) particles because nanoparticles absorb much more power at tolerable AC magnetic fields [3].
- Which is strongly dependent on the particle size and shape, and thus, having well-defined synthetic routes able to produce uniform particles is essential for a rigorous control in temperature.

TYPES OF MAGNETIC NANOPARTICLES

1. Oxides: ferrite

Ferrite nanoparticles are the most explored magnetic nanoparticles up to date. Once the ferrite nanoparticles become smaller than 128 nm (An.huilu *et al 2007*) they become super paramagnetic which prevents self-agglomeration since they exhibit their magnetic behavior only when an external magnetic field is applied. With the external magnetic field switched off, the remanence falls back to zero. Just like non-magnetic oxide nanoparticles, the surface of ferrite nanoparticles is often modified by surfactants, silicones or phosphoric acid derivatives to increase their stability in solution.

2. Metallic with a shell

The metallic core of magnetic nanoparticles may be passivity by gentle oxidation, surfactants, polymers and precious metals. In an oxygen environment, Co nanoparticles form an anti-ferromagnetic Co O layer on the surface of the Co nanoparticle.

Recently, work has explored the synthesis and exchange bias effect in these Co core Co O shell nanoparticles with a gold outer shell. Nanoparticles with a magnetic core consisting either of elementary Iron or Cobalt with a nonreactive shell made of grapheme have been synthesized recently. The advantages compared to ferrite or elemental nanoparticles are:

- Higher magnetization
- Higher stability in acidic and basic solution as well as organic solvents
- Chemistry on the grapheme surface via methods already known for carbon nano tubes.

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 bio molecules 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 bio molecules 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 bio molecules according to the specific applications.

1. Wet precipitation and co-precipitation

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 require 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:

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

Unfortunately, there are also some drawbacks with this procedure. Controlling the pH is vital in order to control the particle size, which is governed by kinetic factors. Nanoparticles with broad particle size distributions and irregular morphologies are usually produced by wet precipitation. Oxidation of the iron (II) precursor involved during synthesis, scaling up is possible but not easy. Finally, since controlling the pH is delicate, it is virtually impossible to simultaneously precipitate a protective coating. After preparation, coating these nanoparticles individually, without aggregation can be difficult [4].

3. Micro emulsion

Micro emulsion Using the micro emulsion technique, metallic cobalt, cobalt/platinum alloys, and gold-coated cobalt/platinum nano particle shave been synthesized in reverse micelles of acetyl trimethly ammonium bromide, using 1-butanol as the co surfactant and octane as the oil phase or carbon coated nanoparticles are produced at rate of > 30 g/h .

Safety and Biocompatibility of Magnetic Nanoparticles

- Toxicity issues are a major concern and are important factors in the context of regenerative medicine and tissue engineering.
- As mentioned previously, the use of MNPs in regenerative medicine requires the labelling of cells (the therapeutic agents) with MNPs which may then be implanted within the body.
- Employing particles which are toxic in nature over a long period of time can significantly diminish the therapeutic efficiency of the cell-based therapy
- It is valid at this point to state that toxicology is defined as the study of adverse effects of chemical, physical, and biological agents in people, animals, and the environment.
- Toxic cellular effects are translated into impaired mitochondrial activity, membrane leakage, and morphological changes.
- In cases where the MNPs are incorporated into the therapy and transplanted within the body, the risk of MNPs migrating through the organism, entering, and accumulating within organs is a constant concern.
- This could trigger an immunological or an inflammatory response by the body.
- These are all highly undesirable consequences. Labeling stem cells for this application therefore demands the preservation of physiological cellular properties and the retention of MNPs over prolonged periods.

APPLICATIONS

A wide variety of applications have been envisaged for this class of particles which include:

Medical diagnostics and treatments

- Magnetic nanoparticles are used in an experimental cancer treatment called magnetic hyperthermia in which the fact that nanoparticles heat when they are placed in an alternative magnetic field is used.
- Another potential treatment of cancer includes attaching magnetic nanoparticles to free-floating cancer cells, allowing them to be captured and carried out of the body.
- Magnetic nanoparticles can be used for the detection of cancer. Blood can be inserted onto a micro fluidic chip with magnetic nanoparticles in it.
- These magnetic nanoparticles are trapped inside due to an externally applied magnetic field as the blood is free to flow through. The magnetic nanoparticles are coated with antibodies targeting cancer cells or proteins.

***IN VIVO* APPLICATIONS**

- Two major factors play an important role for the *in vivo* uses of these particles: size and surface functionality.
- Even without targeting surface legends', super paramagnetic iron oxide NP (SPIOs) diameters greatly affect *in vivo* bio distribution.

- Particles with diameters of 10 to 40 nm including ultra-small SPIOs are important for prolonged blood circulation; they can cross capillary walls and are often phagocytosed by macrophages which traffic to the lymph nodes and bone marrow [5].

1. Therapeutic applications

Hyperthermia: Placing super paramagnetic iron oxide in altering current [AC] magnetic fields randomly flips the magnetization direction between the parallel and anti parallel orientations, allowing the transfer of magnetic energy to the particles in the form of heat, a property that can be used *in vivo* to increase the temperature of tumor tissues to destroy the pathological cells by hyperthermia. Tumor cells are more sensitive to a temperature increase than healthy ones. In past studies, magnetite cationic liposomal nanoparticles and dextran-coated magnetite have been shown to effectively increase the temperature of tumor cells for hyperthermia treatment in cell irradiation.

2. Diagnostic applications

NMR imaging

The development of the NMR imaging technique for clinical diagnosis has prompted the need for a new class of pharmaceuticals, so-called magneto-pharmaceuticals. These drugs must be administered to a patient in order to enhance the image contrast between the normal and diseased tissue and/or indicate the status of organ functions or blood flow.

3. Genetic engineering

Magnetic nanoparticles can be used for a variety of genetics applications. One application is the isolation of mRNA. This can be done quickly – usually within 15 minutes. In this particular application, the magnetic bead is attached to a poly T tail. When mixed with mRNA, the poly A tail of the mRNA will attach to the bead's poly T tail and the isolation takes place simply by placing a magnet on the side of the tube and pouring out the liquid.

IN-VIVO APPLICATION

1. Diagnostic applications

Separation and selection determining trace-level contaminants in environmental samples. Recently, nanometer-sized particles (nanoparticles, NPs) have gained rapid and substantial progress and have a significant impact on sample extraction. SPE offers an excellent alternative to the conventional sample concentration methods, such as liquid-liquid extraction.

2. Industrial applications

Magnetic iron oxides are commonly used as synthetic pigments in ceramics, paints, and porcelain. Magnetic encapsulates may find very important uses in many areas of life and also in various branches of industry. Such materials are interesting from both points of the fundamental study of materials science as well as their applications [6].

Figure 1. Different sizes of Nano particles

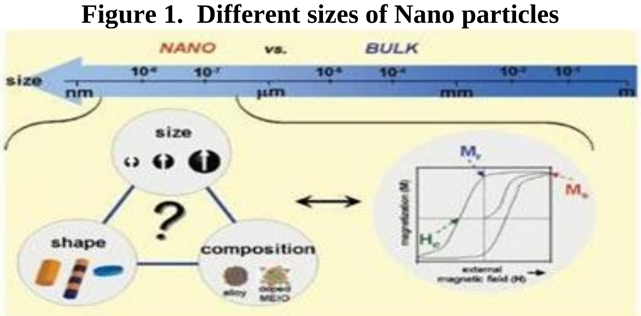


Figure 2. Particle Size Nanoparticles

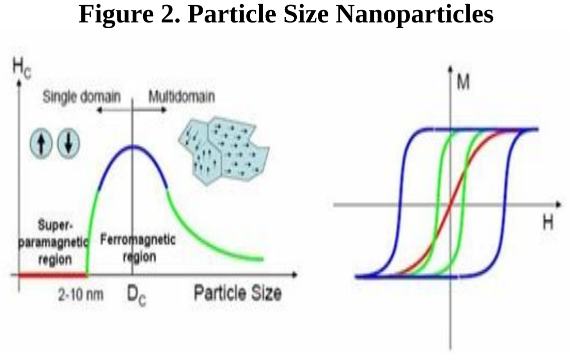
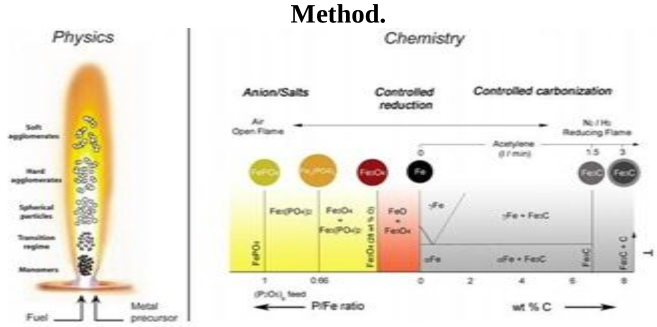
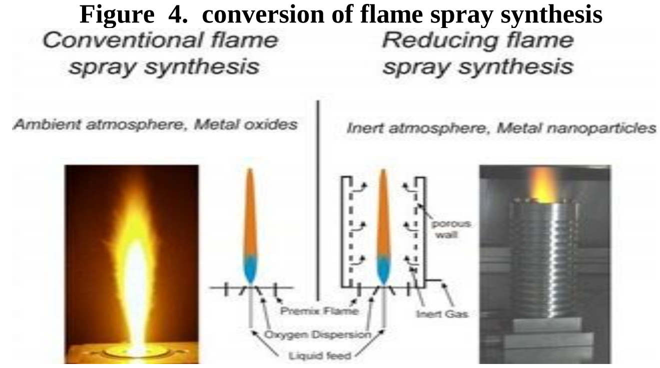


Figure 3. Preparation of Nano particles by Flame spray Method.



Various flame spray conditions and their impact on the resulting nanoparticles.

Figure 4. conversion of flame spray synthesis



Operational layout differences between conventional and reducing flame spray synthesis

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.

REFERENCES

1. An-Hui Lu, An-Hui E, Salabas L and Ferdi Schüth (2007): Magnetic Nanoparticles: Synthesis, Protection, Functionalization, and Application. *Angew. Chem. Int. Ed*, 46(8), 2007, 1222–1244.
2. Athanassiou EK, Evagelos K, Grass RN, Stark WJ. Chemical Aerosol Engineering as a Novel Tool for Material Science from Oxides to Salt and Metal Nanoparticles. *Aerosol. Sci. Tech,* 44(2), 2010, 161–168.
3. Green M. Organometallic based strategies for metal nanocrystal synthesis. *Chem Commun*, 24, 2005, 3002–3011.
4. Bergemann C, Muller-Schulte D, Oster J, Brassard L, Lubbe A, *J Magn. Magn. Mater*, 194, 1999, 45.
5. Elaissari A, Chatterjee J, Hamoudeh M and H Fessi. Chapter 14. Advances in the Preparation and Biomedical Applications of Magnetic Colloids . *In Roque Hidalgo-Alvarez. Structure and Functional Properties of Colloidal Systems*. *CRC Press*, 2010, p. 315–337.
6. Lu AH, Schmidt W, Matoussevitch N, Pnnermann HB, Spliethoff B, Tesche B, Bill E, Kiefer.W, SchVth F. *Angew.Chem*, 116, 2004, 4403.