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Review Article

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Magnetic Nanoparticles-Synthesis, Properties and Potential Applications

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Abstract

Magnetic nanoparticles are classified as nanoparticle that can be manipulated within a magnetic fields. These particles are so small in nature and display all those features which are usually not observed in larger structures when regarded as molecules thus making them useful in numerous biomedical applications.

Keywords: Hydrothermal Amalgamation; Thermal Decomposition; Magneto-caloric Effect; Cobalt nanoparticles

Introduction

Nano sized magnetic nanoparticles display excellent paramagnetic properties which make them useful in numerous applications [1]. Such as assembly of discrete super paramagnetic ferrite nanoparticles in to beaded layouts resulting in increased magnetic potential [2]. Besides these nanoparticles act as carrier molecules for specific ligands or functional groups to deliver them to precise locations under the influence of a peripheral magnetic field [3]. In order to reduce nanoparticle accretion, nanoparticle surface is modified using silica or phosphoric acid based surfactants to enhance their perpetuity in solution [4]. Such treated magnetic nanoparticles is useful in many medical applications such as in cell disruption techniques, immunoassay, clinical diagnostic, drug/DNA delivery etc [5,6].

Synthesis of magnetic nanoparticles

Following are some methods through which magnetic nanoparticles could be fabricated

Chemical and Biological Methods

Currently, chemical precipitation methods for the synthesis of magnetic nanoparticles produces structurally stable nano entities with unique morphology [7].

1. Thermal Decomposition

It is the mostly used method which involves the chemical breakdown of substance at raised temperature [8]. It requires the consumption of organometallic compounds such as acetylacetonates dissolved in organic solvents such as Ethylenediamine, benzyl ether and carbonyls with surfactants such as polyvinyl pyrrolidone, hexadecylamine, oleic acid, oleylamine, cetyltrimethyl ammonium bromide etc. [9,10].

2. Hydrothermal Amalgamation

It involves the use of colloidal solution at high vapor pressure to form magnetic nano particles of definite size and shape [11].

3. Microwave assisted Amalgamation

It employs the heating of solvents or solids with microwave radiation [12].

4. Template assisted Amalgamation

In this process suitable base template is chosen to fabricate nanoparticles of definite size and shape [13].

5. Thermodynamic Assembly of nanostructures

A type of bottom-up nanofabrication approach which organizes magnetic nanoparticles into multidimensional arrays under the effect of an external field [14].

6. Bio based Amalgamation method

Using a biological organism such as plants, microbes, fungi, yeast etc as nanofactories for synthesis of magnetic nanoparticles either intracellularly or extracellularly [15].

Properties of Magnetic Nanoparticles

1. Magnetic Property

Magnetic nanoparticles of size range from 1 to 100 nm display super paramagnetic characteristics caused by thermal fluctuations that is capable of demagnetizing a stable assembly [16]. Thus making them suitable to be used in therapy treatments and targeted drug delivery [17].

2. Magneto-caloric Effect

It is defined as the capability of magnetic nanoparticles to become heated when placed in a magnetic field and when displaced from such field it restores its original temperature [18]. Such feature of

magnetic nanoparticles provides a favorable way for refining therapy treatments [19].

Types of Magnetic Nanoparticles

1. Iron nanoparticles

Iron oxide based nanoparticles offers several advantages such as permanency, low price, non-toxic reagents and physical/chemical plasticity [20]. Thus making them appropriate to be used in medical applications such as drug delivery, magnetic parting, biosensors, and MRI etc [21]. Besides iron based nanoparticles protected with gold, silica or silver coatings re also useful [22].

2. Cobalt nanoparticles

Such magnetic nanoparticles are not that commonly used due to cobalt toxicity issue [23]. However carbon-coated cobalt nanoparticles were embedded with organic polymers for drug delivery [24].

3. Nickel nanoparticles

Methods such as pyrolysis, thermal decomposition, sol-gel process etc were used to synthesize carbon encapsulated Nickel nanoparticles [25].

Applications of Magnetic Nanoparticles

1. Magnetic parting

Magnetic nanoparticles are widely used in bio-separation techniques by labelling the specific biological molecule with theses magnetic entities to be separated under an applied magnetic field [26]. An example is the use of magnetic beads for the separation /ablution of biomolecules [27].

2. Diagnostics

Using magnetic nanoparticles in non-invasive imaging procedures such as magnetic resonance imaging is widely used as diagnostic tools to envisage the assembly and function of tissues [28].

3. Biosensors

Magnetic biosensors are used in the identification of specific molecular targets due to their discrete magnetic properties [29].

4. Drug delivery

Magnetic nanoparticles serves as carriers of the drugs for local drug delivery system for tumorous cells [30].

5. Therapy

Magnetic nanoparticles have been used for targeted therapeutic heating of tumors termed as hyperthermia [31].

Conclusion

Thus magnetic nanoparticles offers numerous advantages for which they are employed in various biomedical and engineering applications.

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