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MAJOR NANOPARTICLES CLASSIFICATIONS AND ITS APPLICATIONS: A REVIEW

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Abstract

Nanotechnology is classified as an emerging technology because of its capacity to modify and build new products with new features and functions that have great promise in a variety of applications. Nanoparticles are in high demand in nanotechnology because of their unique optical, electrical, and mechanical quantum phenomena. Engineered surfaces with customized characteristics such as high surface area, particular reactivity, and capacity to self-assemble on a support surface have boosted their demand in a variety of fields. Inorganic nanoparticles, Organic nanoparticles, and Carbon-based nanoparticles are examples of nanomaterials with unique properties that enable entirely new applications to be discovered.

1. Introduction

Over the last few years, engineering and scientific communities witness the emergent growth of nanoscience and nanotechnology. The prefix "Nano" is derived from Greek word "nanos", meaning dwarf [1]. Within convention of International system of units it is used to indicate reduction factor 10^{-9} [4.5]. The term "nanotechnology" was first introduced by Norio tanigucchi in 1974 [3]. The idea of "NANOTECHNOLOGY" was given in 1959 after a dinner talk "there's plenty of room at the bottom" by Richard Feynman in an American

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physical society at California institute of technology and later were developed by Eric Drexler in 1986 [2]. Nanotechnology and nanoscience got a boost with the development of scanning tunneling microscope in 1981. "NANOTECHNOLOGY" can be defined as a science which design, manipulate, characterize matter at molecular level and create a molecule of dimension range 1-100 nm at least in one direction [4, 5]. In nanotechnology nano particle research received lots of attention because of its innumerable application. Nano particles are usually defined as a particle of matter whose diameter is present in the range of 1-100 nm. Nanoparticles are derived from various materials such as metals, metal oxide, polymers, organic, non-ceramics, carbon and its industrial applications [4, 6].

2. Classification of Nanoparticles

Nanoparticle generally classified on the basis of dimension, size, shape, uniformity, composition and agglomeration. Nanoparticle classify on the basis of electron movement of dimension (i) Zero dimension nanomaterial, all dimension are measured in nanometre for example nanodot. (ii) One dimensional nanoparticle has only one dimension in macroscale, for example nanowire and nanofibre. (iii) Two dimensional nanoparticle cover thin films and nanosheets. (iv) Three dimensional represent material in bulk [7, 8]. Nanomaterial can also be classified on the basis of chemical nature.

2.1 Inorganic Nanoparticle

Inorganic nanoparticle are synthesized from material without carbon and further categorized into metal and metal oxide nanoparticle. Metallic element ranging from s- block, p-block and transition metal are used for synthesis of wide range of nanoparticle [9, 10, and 11]. Metal nanoparticles have been used in coloured windows and glass from pre historic time. Metallic nanoparticles possess unique optoelectronic properties due to surface Plasmon. These nanoparticles consist of Ag, Au, Cu, Al, Pt., Zn etc. Metal oxide nanoparticles possess unique chemical and physical properties due to its high density edge surface site and limited size. Metal oxides nanoparticles are used in production of fuel cell piezoelectric device, fuel cell and as catalysts. These Metal oxides are used as pigment in paint (TiO2), sunscreen, cosmetics (TiO_2, ZnO) WO_x, SnO_2, $Fe2O_3$ photo-catalytic characteristics [12, 13].

• Gold nanoparticle: Since ancient time to middle age, gold in soluble form was used by doctors for the treatment of many diseases such as epilepsy, heart disease, dysentery and syphilis because of its healing power. In 1618, "Francis Anthony published a book on colloidal gold and later on faraday prepares the first gold nanoparticle which is still present in the Royal Society of London [13]. The gold nanoparticle have unique physical and chemical properties which enhance drugs efficiency, drug loading, easily reach to target cell, biocompatibility, non-cytotoxic and can be synthesized from any methods i.e. used for the treatment of tumor [14].

• Silver nanoparticle: Silver nanoparticle receives lots of attention in the field of nanotechnology due to its unique properties such as good conductivity, chemical stabilities, catalytic and most importantly anti-microbial, anti-fungal, anti-inflammatory and anti-viral property. Recently, due to its peculiar properties silver nanoparticles is used in many consumer products, medical device coating, optical sensor, the food industry, in cosmetics, in pharmaceutical industries etc. [15]

• Copper nanoparticles: Cu is an element of 3d transition metal and has some unique physical and chemical properties. Cu possess wide range of oxidation states (cuo, cuI, cuII, cuIII) i.e. cu based material undergo wide range of reactions Due to its low cost and admirable electrical conductivity the demand of Cu nanoparticle is increase in the field of electric circuit [16]. Cu nanoparticles have various applications in the field of water treatment, catalysts and solar cell [17].

2.2 Organic Nanoparticle

Organic nanoparticle can be defined as a solid particle present in the diameter range of 10nm to 1um mainly composed of organic compound (lipid or polymer) [18]. Liposomes, dendrimers, carbon nanomaterials and polymeric micelles are an example of organic nanoparticles. Dendrimers are nano-sized highly branched polymeric molecules which are mostly used in pharmaceuticals and medical areas such as gene delivery, boron neutron capture therapy etc. Liposomes are spherical particles consists of one or more phospholipids and because of its structure it act as an ampiphilic, hydrophilic and lipophilic in nature. Phospholipids in liposomes possess a unique property of liquid crystalline transition temperature. Recently, Liposomes have been used to fortify dairy products with vitamins [19].

2.3 Carbon-Based Nanoparticles

Carbon based nanoparticles are very trendy in the field of nanoscience, material science, engineering and technology, carbon nanostructure are comprised of different low-dimension allotropes of carbon such as fullerene, carbon-nanotubes, graphene etc. Carbon nanostructured possess a unique hybridization properties and sensitivity to perturbation during synthesis as a result of which fine manipulation take place in mechanical properties. Carbon nanostructured possess unique such as electrical, mechanical and structure diversity and has been used in various biological application including drug delivery, tissue engineering, bio sensing, imaging, diagnosis and cancer treatment [20, 21].

• Carbon nanotube: Iizima was discovered the first to find the carbon nanotube in 1991. Single-walled carbon nanotubes and multiwalled carbon nanotubes are two types of carbon nanotubes [22, 23].

• Graphene: Graphene is a building-block of other carbon allotropes because when it wrapped form fullerene, when stacked together form graphite and when rolled form nanotube. The properties of graphite are excellent, including a wide surface region, strong conductivity, and thermal stability and high mechanical strength and have sp2 hybridized honeycomb lattice structure with zero energy band gaps [24].

• Fullerene: Fullerene (C60) is also known as buckyballs because of its spherical structure. In 1980 H. Kroto, R. Smalley and R. Curl detect first fullerene and its name was dedicated to buckminister fuller [25]. Fullerenes are also used to construct biosensor because it exhibit good biocompatibility, low background current, high chemical stability, high carrier capacity etc. [26].

3. Approaches to Make Nanotechnology Products

There are two different approaches are available for making products of nanoscale features and attributes [27].

• Bottom-Up Approach: In the bottom method, nanoparticles are created by the self-assembly of tiny atoms, which then expand into nanoscale particles. This method is useful for chemical synthesis and biological synthesis.

• Top-Down Approach: In this approach mechanical grinding or physical method is used to break-down complex structure material into nanostructure material.

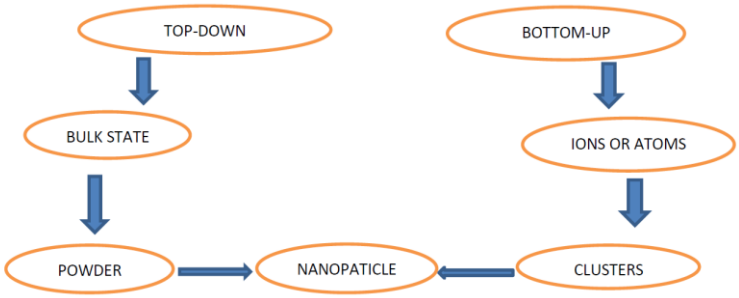

Figure 1. The top-down and bottom-up approaches to nanoparticle synthesis mechanisms [28].

4. Conclusion

Nanotechnology is a branch of science which shows an interdisciplinary relationship between biology, engineering, physics, chemistry, medicine and agriculture etc. At nano-dimension the properties of particles is different from that at bulk stage. These properties of nanoparticles increase their demands in day to day life and applications in the various fields of medicine, agriculture, food, electronics, environmental bionanoremediation, textiles etc.

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