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Review on Classification, Synthesis of Nanoparticles & Their Applications

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Abstract

From the past few decades, there has been considerable research in the area of nanotechnology using nanoparticles such as metals, semiconductors and metal oxide. The particles having a size ranging from 1 to 100 nm with one or more dimensions are referred to as nanoparticles. The nanoparticles have various enhanced properties such as high reactivity, strength, surface area, stability, sensitivity etc. Generally, nanoparticles are classified into two groups such as organic nanoparticles and inorganic nanoparticles. The nanoparticles are synthesized by the bottom-up and top-down methods. The current review focuses on nanoparticle classification, synthesis, measurement technology and advanced application related to nanotechnology.

Keywords:- *Nanoparticles, Synthesis of nanoparticle, Inorganic nanoparticles and Organic nanoparticle.*

INTRODUCTION

The nanoparticles are a fundamental component of nanotechnology, having a particle size between 1 to 100 nm. The nanoparticles are made up of Carbon, metal, organic matter or metal oxides [1]. The nanoparticle exhibits a unique biological, chemical and physical property due to their respective higher scale particles [2]. Since ancient times, nanoparticles have been used in medicine and pottery [3]. The nanoparticles have various applications due to their large surface area to volume, increased reactivity or stability in a chemical process, enhanced mechanical strength [2].

The nanoparticles are available in different sizes, shapes and dimensions. According to dimension, the nanoparticles are zero dimension, one dimension, two-dimension and three-dimension.In the case of zero-dimensional nanoparticles, the length, breadth and height are fixed at a single point. For Ex. Nano dots. One dimensional nanoparticle has only one parameter for ex. Graphene, length and breadth for two dimensional nanoparticles, for ex. Carbon nanotubes, while three-dimensional nanoparticles have all parameters such as length, breadth and height, for example, gold nanoparticles [4].

Currently, different metallic nanomaterials are produced by using Copper, Zinc, Titanium, Magnesium, Gold, and Alginate [1]. The nanoparticles can be synthesized by physical, chemical, biological and hybrid methods. Physical and Chemical methods are more popular for the synthesis of nanoparticles. There is a limitation to the use of nanoparticles in biomedical and clinical fields [5]. The following parameters should be considered while synthesizing nanoparticles are neutral PH, low cost and environment-friendly fashion. The more stable nanoparticles are formed when synthesized from plants, and the process of synthesis is also fast [3].

Basically, nanoparticles are classified into two groups they are inorganic nanoparticles and organic nanoparticles. Carbon nanoparticles are organic nanoparticles, while magnetic nanoparticles, semiconductor nanoparticles are inorganic nanoparticles [7].

CLASSIFICATION OF NANO--PARTICLES

Generally, nanoparticles are classified into organic nanoparticles and inorganic nanoparticles.

Organic Nanoparticles

Commonly known biodegradable, non-toxic nanoparticles or polymers are dentrimers, micelles, liposomes and ferritin etc. Micelles and liposomes are also known as nanocapsules. Due to the presence of a hollow core and sensitivity to heat and light, nanocapsules are an ideal choice for drug delivery. As organic nanoparticles can be injected into specific parts of the body, they are most widely used in drug delivery systems [2].

Liposomes are sphere-shaped vesicles to carry a compound of interest having one or more phospholipid bilayer. Liposomes are involved in encapsulation to entrap unstable compounds in food and farming industries.

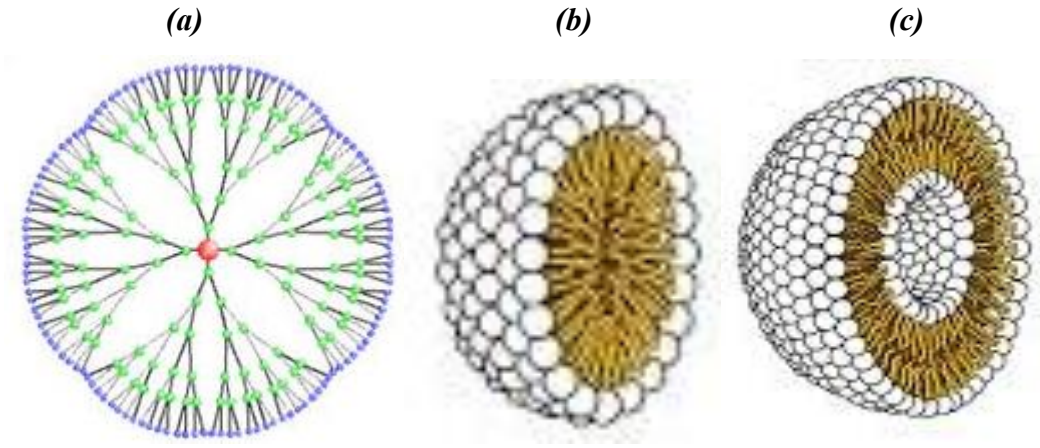

Figure 1: Organic Nanoparticles a) Dentrimers b) Micelles c) Liposome

Liposomes are sphere-shaped vesicles to carry a compound of interest having one or more phospholipid bilayer. Liposomes are involved in encapsulation to entrap unstable compounds in food and farming industries. Dentrimers came from two Greek words: "Dentron" meaning tree and "Meros" meaning part. Dentrimers are three dimensional, globular, mono disperse, hyper-branched synthetic polymer. Micelles are alternate carrier system to emulsion, liposomes and polymeric nanoparticles [6].

Inorganic Nanoparticles

Inorganic nanoparticles are not made up of carbon, categorized into metal and metal oxide nanoparticles.

1. Metal based

Those nanoparticles which are synthesized from metals by destructive or constructive methods are metal-based nanoparticles. Almost all metals can be synthesized into their nanoparticles [2]. Aluminium, Cadmium, Cobalt, Copper, Gold, Iron, Lead, Silver, Zinc are commonly used metals for nanoparticle synthesis. Silver nanoparticles are most effective due to its good antimicrobial efficacy against bacteria, viruses and other eukaryotic microorganisms [5]. The plants such as *azadirachtaindica, capsicum annum, carica papaya* are used for the synthesis of silver nanoparticles. In immunochemical studies, the gold nanoparticles are used for the identification of protein interaction. Also, in DNA, figure printing is used as a lab tracer to detect the presence of DNA in a sample. The aminoglycoside antibiotics like streptomycin, gentamycin and neomycin are detected by gold nanoparticles. Gold nanorods are used to detect cancer stem cells, identification of different classes of bacteria and diagnosis of cancer [5].

2. Metal oxide based

To modify the properties of respective metal-based nanoparticles, metal oxide-based nanoparticles are synthesized [7]. For ex. Iron oxides are synthesised from Iron by oxidation in the presence of oxygen at room temperature. Iron oxide nanoparticles are more reactive than Iron nanoparticles. Due to increased reactivity and efficiency, the metal oxide-based nanoparticles are synthesized. Aluminum oxide, Cerium oxide, Iron oxide, Silicon dioxide, Titanium oxide, Zinc oxide is commonly synthesized metal-based nanoparticles. Another type of nanoparticle is a carbon-based nanoparticle made up of carbon [2].

SYNTHESIS OF NANOPARTICLE

The bottoms-up or top-down methods are used for the synthesis of nanoparticles.See below**figure 2.**

Top-downMethod

In this method large size bulk materials are broken into a nano-size particle, could be done by million/ Attrition [8] (Mechanical milling), electro exploding wire technique [8], Laser ablation, sputtering, thermal decomposition [2]. It is not suitable for large scale production because it requires more energy. It is a quick manufacturing process. The drawback of the top-down method is imperfections of surface structure [8]. Nano emulsion is a good example of nanoparticle synthesis by mechanical process [9]. Cu Nanoparticle synthesized by electro exploding wire technique of top-down method [8].

Bottom-up Method

In this method, the buildup of material from the molecule by molecule, atom by atom, cluster by cluster [8] could be done by sol-gel, spinning chemical vapour deposition, pyrolysis, Biosynthesis [2].The physical forces acting on the Nanostructure are used to combine the particles into a larger one during the assembling process. Nano technologists mostly prefer the bottom-up method for the synthesis of complex Nanostructures because of precise control of particle size [8].

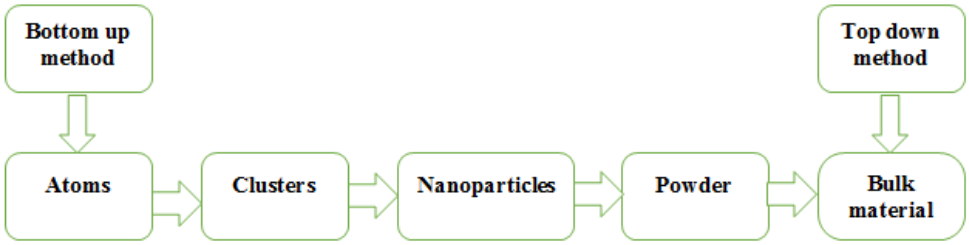

Figure 2: Synthesis process of nanoparticles

MEASUREMENT TECHNOLOGY

The Characteristic of Nanoparticles can be measured by a number of instruments, for example, Dynamic Light Scattering (DLS) and Electron Microscopy (EM) [8]. DLS technique is used to evaluate the particle size distribution. The mechanism behind the DLS measurement is based on the particle motility due to Brownian motion.

The size and morphology of drug particles are measured by an electron microscope, one of the single-particle techniques. The electron microscope includes Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM). The mechanism behind EM measurement is that beam of the electron is transmitted through a particle, interacting with it, and as a result, an image is formed from the interaction of the electron transmitted through the particle. The image is magnified and focused onto an imaging device [9].

APPLICATIONS OF NANOPARTICLES

Food

Nano food is defined as food thatis manufactured by the use of nanotechnology techniques. The purpose behind the development of nano food is to improve food safety, nutrition and flavour enhancement and cutting production and consumer cost [6].

Waste Water Effluent Treatment

The Nanoparticles are used in wastewater effluent treatment because the surface area to volume ratio is higher in Nanoparticles, which absorbs more energy from light. Thus produces more hydroxyl radicle, which oxidise the organic pollutants. Nanocatalyst like TiO2, ZnO, MgO, CuO etc. takes part in photocatalytic reactions which is carried out in the presence of light [10].

Food Packaging

Nowadays, food packaging materials like plastics made up of Polyethylene, Polypropylene, Polyvinyl alcohols are used, but these are harmful as well as non-biodegradable [11]. Many studies are going on to develop Biopolymer to have eco-friendly food packaging material. But in comparison to plastic, it has low barrier properties. The low barrier property of Biopolymer can be enhanced by adding a filler matrix, which is made up of nanoparticles. When food gets spoiled certain types of gases to get produced. To detect these gases, the sensors like nano sensors are being added to food packaging material. It also prevents the permeation and transpiration of gases, for ex., to prevent oxygen penetration into the package and simultaneously to stop the moisture loss from the product; silica

nanoparticles are used in food packaging material [10].

Medicines

In the field of medicine, nano science and technology are currently developed to detect the disease such as atherosclerosis, cancer at early stages and targeted drug delivery for tissue of choice or a cell [8]. To the specific cells, the drug can be delivered using nanoparticles [2]. The time of drug release and targeting the specific diseased cell are two important aspects of nanotechnology in drug delivery that improve drug availability [8]. The use of gold in medicine is for memory enhancement. To enhance the mental fitness of a baby, gold is included in certain medicine preparation [12].

Anti-microbial Activity

The metal nanoparticles have anti-microbial activity. The bactericidal effect of the metal nanoparticle is due to their small size and high surface to volume ratio, which allows them to closely interact with microbial membranes [8]. To inhibit the growth of gram-positive and gram-negative bacteria, silver and gold nanoparticles are effective [13]. The fungus Pestalotia synthesizes silver nanoparticles, which show bactericidal effect against human pathogens like S. aureus and S. typhi [8].

Biosensor

Due to electronic and optical properties, nanoparticles can be used in biosensors applications. Spherical Selenium nanoparticles synthesized by Bacillus Subtilis having a diameter ranging from 50-400 nm. The highly anisotropic, one-dimensional trigonal structure is formed from spherical monoclinic selenium nanoparticles after one day at room temperature since they are synthesis. Due to the high surface to volume ratio, good adhesive ability and biocompatibility were implied as enhancing and settled materials to build up HRP (horseradish peroxidase) biosensors having good electrocatalytic activity towards the reduction of hydrogen peroxide [6].

Agriculture

The grasserie disease in silkworm caused by the virus B. mori nuclear polyhedrosis virus is controlled by silver nanoparticles, Zinc oxide, Titanium oxide nanoparticles [8].

Catalysis

Due to high surface area, nanoparticles have higher catalytic activity. In the production of chemicals, the nanoparticles

function as an efficient catalyst due to their large surface to volume ratio [2].

Cosmetics and Sunscreens

The Titanium dioxide and zinc oxide nanoparticles are included in sunscreen due to their transparency to visible light and absorb and reflect UV rays. In some lipsticks, the Iron oxide nanoparticles are used as pigment [2].

Textile

Due to some of the properties of nanoparticles like water repellence wrinkle resistance, antibacterial, antistatic, UV protection are used in textile industries [8].

CONCLUSION

Nanoparticles have become significant in recent years, such as energy, healthcare, environment, agriculture etc., due to their incredible properties. Being able to convert poorly soluble, poorly absorbed and labile biologically active substance into promising deliverable substance, the nanoparticle technology has great potential.

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