WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.084
Volume 12, Issue 2, 517-524. Review Article ISSN 2277– 7105

A REVIEW ON THE NANOPARTICLES

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Article Received on
26 November 2022,
Revised on 16 Dec. 2022,
Accepted on 07 Jan. 2023
DOI: 10.20959/wjpr20232-26945

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❖ ABSTRACT

As per ISO standards, nanoparticles are particles of sizes ranging from 1 to 100nm with one or more dimensions. The nanoparticles are generally classified into the organic, inorganic and carbon based particles in nanometric scale that has improved properties compared to larger sizes of respective materials. The nanoparticles show enhanced properties such as high reactivity, strength, surface area, sensitivity, stability, etc. because of their small size. The nanoparticles are synthesized by various methods for research and commercial uses that are classified into three main types namely physical, chemical and mechanical processes that has seen a vast improvement over time. This paper presents a review on nanoparticles, their types, properties, synthesis methods and its applications in the field of environment.

KEYWORD: Nano-particle, Organic, Inorganic, Nanotechnology.

❖ INTRODUCTION

Nanotechnology has gained huge attention over time. The fundamental component of nanotechnology is the nanoparticles. Nanoparticles are particles between 1 and 100 nanometres in size and are made up of carbon, metal, metal oxides or organic matter.[1] The nanoparticles exhibit a unique physical, chemical and biological properties at nanoscale compared to their respective particles at higher scales. This phenomenon is due to a relatively larger surface area to the volume, increased reactivity or stability in a chemical process, enhanced mechanical strength, etc.[2] These properties of nanoparticles have led to its use various applications. The nanoparticles differ from various dimensions, to shapes and sizes apart from their material.[3] A nanoparticles can be either a zero dimensional where the length, breadth and height is fixed at a single point for example nanodots, one dimensional

where it can possess only one parameter for example graphene, two dimensional where it has length and breadth for example carbon nanotubes or three dimensional where it has all the parameters such as length, breadth and height for example gold nanoparticles. The nanoparticles are of different shape, size and structure. It be spherical, cylindrical, tubular, conical, hollow core, spiral, flat, etc. or irregular and differ from 1 nm to 100 nm in size. The surface can be a uniform or irregular with surface variations. Some nanoparticles are crystalline or amorphous with single or multi crystal solids either loose or agglomerated.[4]

❖ CLASSIFICATION OF NANOPARTICLES

The nanoparticles are generally classified into the organic, inorganic and carbon based.

1. Organic Nanoparticles

Dendrimers, micelles, liposomes and ferritin, etc. are commonly knows the organic nanoparticles or polymers. These nanoparticles are biodegradable, non-toxic, and some particles such as micelles and liposomes has a hollow core, also known as nanocapsules and are sensitive to thermal and electromagnetic radiation such as heat and light.[5] These unique characteristics make them an ideal choice for drug delivery. The drug carrying capacity, its stability and delivery systems, either entrapped drug or adsorbed drug system determines their field of applications and their efficiency apart from their normal characteristics such as the size, composition, surface morphology, etc.

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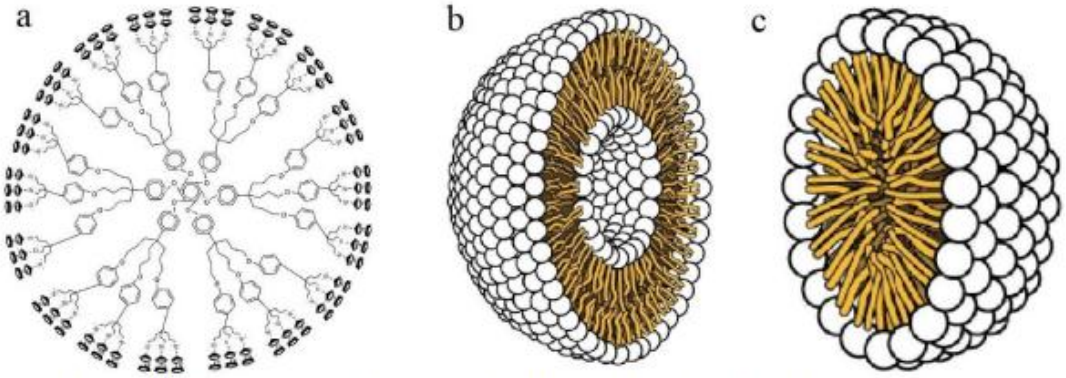

Figure 1. Organic nanoparticles: a – Dendrimers, b – Liposomes and c – micelles.

2. Inorganic nanoparticles

Inorganic nanoparticles are particles that are not made up of carbon. Metal and metal oxide based nanoparticles are generally categorized as inorganic nanoparticles.

a. Metal based

Nanoparticles that are synthesized from metals to nanometric sizes either by destructive or constructive methods are metal based nanoparticles. Almost all the metals can be synthesized into their nanoparticles.[6] The commonly used metals for nanoparticles synthesis are aluminum (Al), cadmium (Cd), cobalt (Co), copper (Cu), gold (Au), iron (Fe), lead (Pb), silver (Ag) and zinc (Zn). The nanoparticles have distinctive properties such sizes as low as 10 to 100nm, surface characteristics like high surface area to volume ratio, pore size, surface charge and surface charge density, crystalline and amorphous structures, shapes like spherical and cylindrical and colour, reactivity and sensitivity to environmental factors such as air, moisture, heat and sunlight etc.

b. Metal oxides based

The metal oxide based nanoparticles are synthesized to modify the properties of their respective metal based nanoparticles, for example nanoparticles of iron (Fe) instantly oxidises to iron oxide (Fe2O3) in the presence of oxygen at room temperature that increases its reactivity compared to iron nanoparticles. Metal oxide nanoparticles are synthesized mainly due to their increased reactivity and efficiency.[7] The commonly synthesized are Aluminium oxide (Al2O3).

3. Carbon based

The nanoparticles made completely of carbon are knows as carbon based.[8] They can be classified into fullerenes, graphene, carbon nano tubes (CNT), carbon nanofibers and carbon black and sometimes activated carbon in nano size.

a. Fullerenes

Fullerenes (C60) are a carbon molecule that is spherical in shape and made up of carbon atoms held together by sp2 hybridization. About 28 to 1500 carbon atoms forms the spherical structure with diameters up to 8.2 nm for a single layer and 4 to 36 nm for multi-layered fullerenes.

b. Graphene

Graphene is an allotrope of carbon. Graphene is a hexagonal network of honeycomb lattice made up of carbon atoms in a two dimensional planar surface. Generally the thickness of the graphene sheet is around 1 nm.

c. Carbon Nano Tubes (CNT)

Carbon Nano Tubes (CNT), a graphene nanofoil with a honeycomb lattice of carbon atoms is wound into hollow cylinders to form nanotubes of diameters as low as 0.7 nm for a single layered and 100 nm for multi-layered CNT and length varying from a few micrometres to several millimetres. The ends can either be hollow or closed by a half fullerene molecule.

d. Carbon Nanofiber

The same graphene nanofoils are used to produce carbon nanofiber as CNT but wound into a cone or cup shape instead of a regular cylindrical tubes.

e. Carbon black

An amorphous material made up of carbon, generally spherical in shape with diameters from 20 to 70 nm. The interaction between the particles is so high that they bound in aggregates and around 500 nm agglomerates are formed.

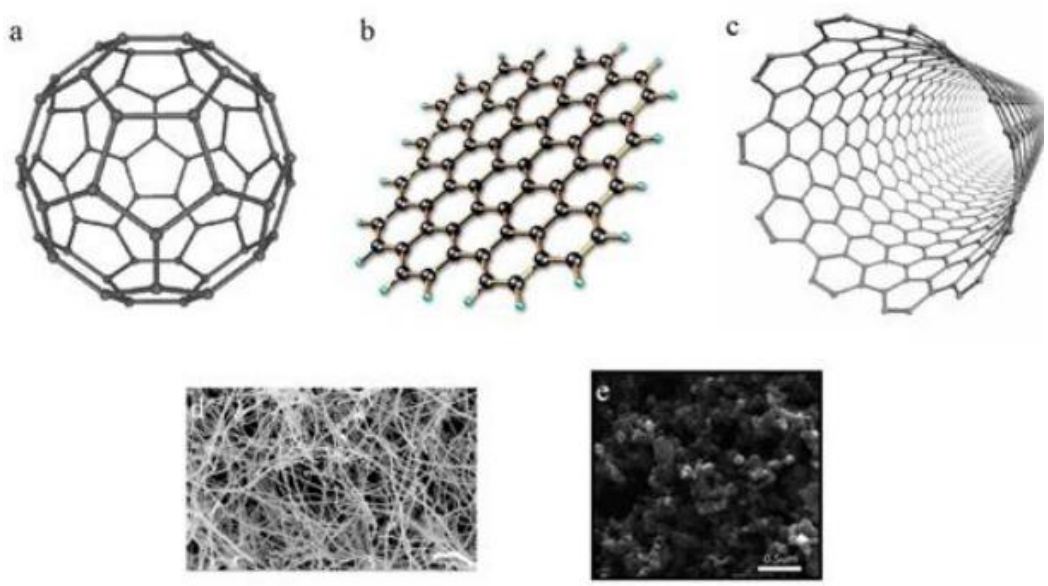

Figure 2. Carbon based nanoparticles: a – fullerenes, b – graphene, c – carbon nanotubes, d – carbon nanofibers and e – carbon black

Applications

Below are some of the significant applications of nanoparticles.

1. Cosmetics and Sunscreens

The conventional ultraviolet (UV) protection sunscreen lacks long-term stability during usage. The sunscreen including nanoparticles such as titanium dioxide provides numerous advantages. The UV protection property of titanium oxide and zinc oxide nanoparticles as they are transparent to visible light as well as absorb and reflect UV rays found their way to be used in some sunscreens. Some lipsticks use iron oxide nanoparticles as a pigment.[8]

2. Electronics

The higher necessity for large size and high brightness displays in recent days that are used in the computer monitors and television is encouraging the use of nanoparticles in the display technology. For example nano-crystalline lead telluride, cadmium sulphide, zinc selenide and sulphide, are used in the light emitting diodes (LED) of modern displays.[9] The development in portable consumer electronics such as mobile phones and laptop computers led to the enormous demand for compact, lightweight and high capacity batteries. Nanoparticles are the ideal choice for separator plates in batteries. A considerable more energy can be stored compared to traditional batteries due to their foam like (aerogel) structure. Batteries made from nano-crystalline nickel and metal hydrides, due to their large surface area require less recharging and last longer.[10] The increase in electrical conductivity of nanoparticles is used

to detect gases like NO2 and NH3.[11] This is due to increase in the pores of nanoparticles due to charge transfer from nanoparticles to NO2 as the gas molecules bind them together making them better gas sensors.

3. Catalysis

Nanoparticles contain high surface area that offers higher catalytic activity. Due to their extremely large surface to volume ratio the nanoparticles function as efficient catalyst in the production of chemicals.[12] One of the important applications is the use of platinum nanoparticles in the automotive catalytic converters as they reduce the amount of platinum required due to very high surface area of the nanoparticles thus reducing the cost significantly and improving performance. Some chemical reactions for example, reduction of nickel oxide to metal nickel (Ni) are performed using nanoparticles.

4. Medicine

Nanotechnology has improved the medical field by use of nanoparticles in drug delivery. The drug can be delivered to specific cells using nanoparticles.[13] The total drug consumption and side effects are significantly lowered by placing the drug in the required area in required dosage. This method reduces the cost and side effects. The reproduction and repair of damaged tissue (Tissue engineering) can be carried out with the help nanotechnology. The traditional treatments such as artificial implants and organ transplants can be replaced by tissue engineering. One such example is the growth of bones carbon nanotube scaffolds.[14] The use of gold in medicine is not new. In Ayurveda an Indian medical system, gold is used in several practices. One common prescription is the use of gold for memory enhancement. To enhance the mental fitness of baby gold is included in certain medical preparations.[15]

CONCLUSION

Nanotechnology is improving our everyday lives by enhancing the performance and efficiency of everyday objects. It provides a clean environment by providing safer air and water, and clean renewable energy for a sustainable future. Nanotechnology has gained a wide attention where more investment is made for the research and development by top institutions, industries and organizations. Nanotechnology has established to be an advanced field of science where extensive research is carried out to implement the technology. It is being tested for various new applications to increase the efficiency and performance of the object or process and subsequently reduce the cost so that it is accessible for everyone. The nanotechnology has a great future due to its efficiency and environmental friendly property.

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