A STUDY ON GREEN SYNTHESIS, CHARACTERIZATION AND APPLICATION OF NANOPARTICLES (NPS)*

BY

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Abstract
In the range of 1 to 100 nm, NPs are tinier and tinier materials. They can be categorised according to their characteristics, such as their shape or size. Fullerenes, metal NPs, ceramic NPs, and polymeric NPs are among the various groups. High surface area and nanoscale size confer special physical and chemical properties on NPs. Depending on the size of the object, it is claimed that the absorption in the visible range causes it to appear in different hues. Depending on their unique size, shape, and structure, they have a wide range of properties. Catalysis, imaging, medicinal applications, energy-based research, and environmental applications are some of the commercial and household uses that these materials are well-suited for. Lead, mercury, and tin heavy metal NPs have been found to be inflexible and robust, making it difficult to degrade them, which can lead to a variety of environmental toxicity issues.
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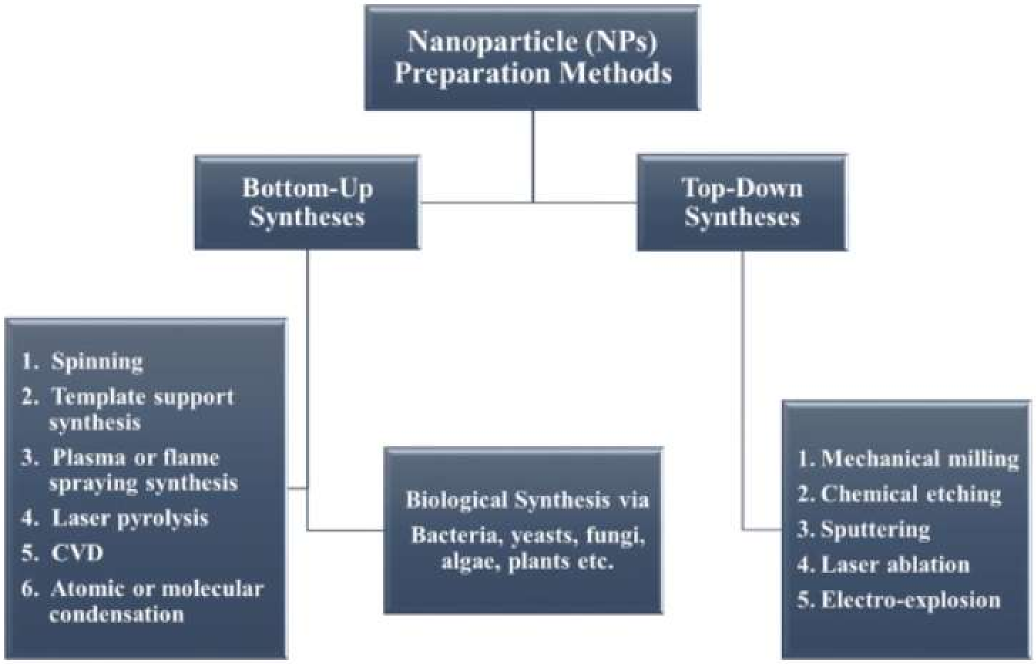
Introduction

Research into nanoparticles (NPs) and nanostructured materials (NSMs) is ongoing, and this area of technology and business is expanding rapidly across a wide range of fields. The adjustable physicochemical properties of NPs and NSMs, such as melting point, wetability, electrical and thermal conductivity, catalytic activity, light absorption and scattering, and other characteristics, have made them prominent in technological advancements. [1] International System of Units (Système international d'unités, SI) unit of length 10-9 metres is called a nanometer. NMs are theoretically characterised as materials with a diameter ranging from 1 to 100 nm and a length ranging from 1–1000 nm in at least one dimension.

Synthesis of nanoparticles

The synthesis of NPs can be done in a variety of ways, but the two most common strategies are the 1) bottom-up approach and the 2) top-down approach (Fig. 1). Based on the operation, reaction condition, and protocol chosen, these techniques are further divided into numerous subclasses. [2]



The top-down (a) and bottom-up (b) synthesis methods for NPs are shown in Fig. 1.

Classification of nanomaterials

NPs and NSMs can be categorised into four material-based groups, which are:

- Carbon-based nanomaterials

  Generally, these NMs are made out of carbon, and can be found in the form of hollow tubes, ellipsoids, or spheres, among other shapes and forms. Carbon-based NMs include fullerenes (C60), carbon nanotubes (CNTs), carbon nanofibers, carbon black, graphene (Gr), and carbon onions. For the manufacturing of these carbon-based materials, laser ablation, arc discharge, and chemical vapour deposition (CVD) are among the most essential techniques. [3]

- Inorganic-based nanomaterials

  NSMs and metal oxide NPs are among the NMs in this group. Metal NPs, such as Au or Ag, metal oxide NPs, such as TiO_2 and ZnO NPs, and semiconductor NPs, such as silicon and ceramics, can all be generated from these NMs.

- Organic-based nanomaterials

  Carbon- and inorganic-based NMs are excluded from this category, as are NMs derived primarily from organic matter. Dendrimers, micelles, liposomes, and polymer NPs can all be made from organic NMs by using noncovalent (weak) interactions in the self-assembly and design of molecules.

- Composite-based nanomaterials

  One phase on the nanoscale dimension, these multiphase NPs and NSMs can either mix NPs with each other or with larger or bulk-type materials (e.g., hybrid nanofibers) or more complex structures, including metal-organic frameworks. Composites can be made from any mix of NMs based on carbon, metal, or organic components and bulk materials based on metal, ceramic, or polymer. [4]

Review of Literature

NPs are not simple molecules itself and therefore composed of three layers i.e. (a) The surface layer, which can be functionalized with a range of small molecules, metal ions, surfactants, and polymers. (b) The inside layer, which can be functionalized with a variety of small molecules, metals, and polymers. There is a core and a shell layer. (c) The core refers to the actual NP, whereas the shell layer is the outermost layer of the NP and is chemically distinct from the core (Shin et al., 2016) [5]

In the realm of carbon-based NPs, there are two main types: fullerenes and carbon nanotubes (CNTs). Allotropic forms of carbon, such as fullerenes, contain nanomaterials formed of globular hollow cages. Because of their electrical conductivity, high strength, structure, electron affinity, and adaptability, they have generated significant economic interest (Astefanei et al., 2015) [6]

Last few years there has been an increasing interest in developing printable electronics due to the possibility for low-cost, wide area electronics for flexible displays, sensors that can be printed. For the mass manufacture of new types of electronics, printed electronics using diverse functional inks, such as metallic and organic electronic molecules and carbon nanotube (CNT) and ceramic nanoparticle (NP) ink, have been anticipated (Kosmala et al., 2011) [7]

In the electronic industry, when novel semiconducting materials were discovered, the shift from vacuum tubes to diodes and transistors, and ultimately to microchips, is an excellent illustration of how scientific discovery and technological advancement may work together harmoniously (Cushing et al., 2004). [8]

It is important to highlight that NPs are easy to manipulate and reversibly assembled, allowing for the insertion of NPs into electrical, electronic, and optical devices such as "bottom up" or "self-assembly" techniques, which are the benchmark of nanotechnology (O'Brien et al., 2001). [9]

Objectives

- To investigate nanoparticle synthesis methods
- To learn more about the different types of nanoparticles.
- To learn how to synthesise using the TEM method
- To look into the elements that influence the production of biological matter.

Research Methodology

Methodology in a research paper refers to a discussion of the specific procedures employed in the study. Theoretical principles are also covered in this discussion, which aid in the selection and application of approaches. It's a descriptive research based on secondary data acquired from a range of sources, including books, education and development magazines and scholarly articles, government publications and printed reference materials.

Result and Discussion

Insight into the morphology of NPs is always sought after, as morphology has a significant impact on the majority of NPs' attributes. Microscopical techniques like polarized optical microscopy (POM), SEM, and TEM are essential for morphological investigations, but there are other methods for characterising them as well. [10]

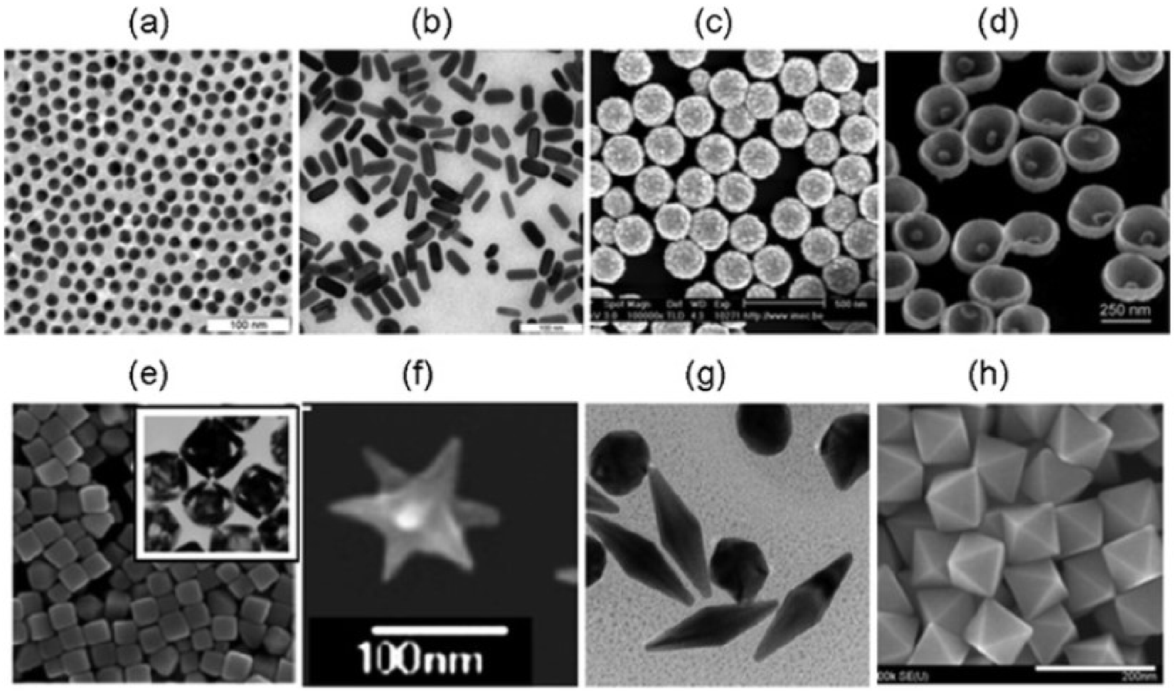


Fig. 2, we see TEM images of gold NPs generated using a variety of methods.

This is because the electron transmittance concept of TEM allows it to deliver information about the bulk material at any magnification level, from low to high magnifications. Gold NPs of various morphologies can be investigated using this method. Figure 2 shows TEM images of gold nanoparticles with a variety of shapes and techniques of production. [11]

As metal concentrations rise, the ability of organisms to survive has increased. Harmful metals may be rendered less toxic or even non-toxic by these organisms, which can modify their chemical makeup. The "consequence" of an organism's resistance mechanism against a certain metal is the production of nanoparticles (Fig 3). [12]

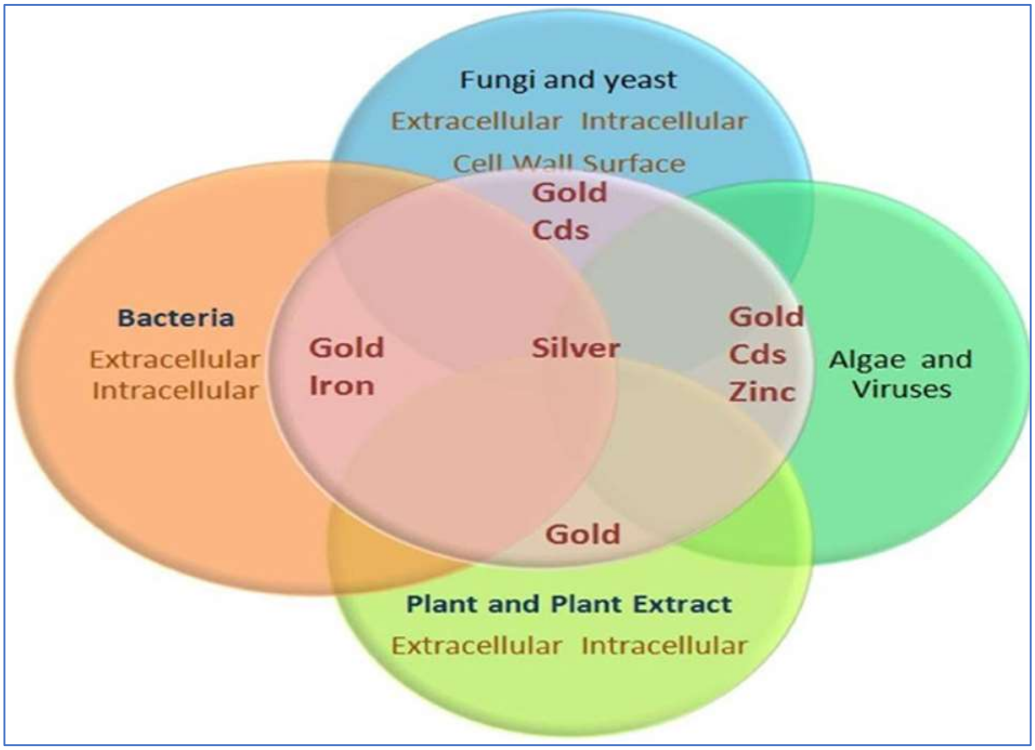


Fig. 3 shows a variety of nanoparticle synthesis methods.

Particle shape and size can be altered by adjusting parameters such as the reaction duration and reactant concentrations as well as pH and temperature (Table 1). [13-14]

Biological synthesis of metal nanoparticles is influenced by several factors, as shown in Table 1.

Factors	Influence on biological synthesis of metal nanoparticles
pH	Size and shape of the synthesized nanoparticle
Reactant concentration	Shape of the synthesized nanoparticles
Reaction time	Size and shape of the synthesized nanoparticle
Reaction temperature	Size, shape, yield and stability of the synthesized nanoparticle

In order to comprehend the function of environmental factors in optimising biologically synthesised metallic NPs, such parameters are necessary to understand the role of environmental factors. [15]

Conclusion

NPs have a vast surface area due to their small size, which makes them appropriate for a wide range of applications. These materials' photocatalytic value is boosted even further by their optical characteristics, which are prominent at that size. It is possible to manipulate the shape, size, and magnetic characteristics of NPs using synthetic methods. There are various health risks associated with NPs' unchecked use and discharge into the natural environment that should be taken into account when working to make NPs more convenient and environmentally friendly.

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