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"together we can and we will make a difference"

A BRIEF REVIEW: OPTICAL AND ELECTRICAL PROPERTIES AND PARTICLE SIZE ANALYSIS TREATMENT OF SYNTHESIS OF METALLIC NANOPARTICLES

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ABSTRACT

This review paper focuses on metal oxide nanoparticles synthesized via the wet-chemical, Co-precipitation, and sol-gel method. New advance technology is already in the research field providing a powerful tool for producing nanomaterials. In this review concept, good quality materials are used for the production of nanoparticles, and the production of metal nanoparticles. Some metal materials are porous, crystalline materials, which consist of metal centers. Nanomaterials structures demonstrate high surface area, open metal sites, and large void space. Nanomaterials have become an integral component of products as diverse as high-performance materials, sunscreens, performance coatings, and plastic composites. This review article focuses on different methods of nanoparticle preparations and their advantages, properties, limitations, and applications.

Keywords: *Advance Technology, Nanomaterials, Nanoparticles, High Performance Materials, Integral Component, Different Methods etc.*

INTRODUCTION

Metallic Nanoparticles (NPs) are part of the big scientific field of nanotechnology. Nanoparticles are used in many fields like chemistry, physics, biology, and many other research areas. Metallic nanoparticles (MNPs) have a metal core composed of inorganic metal or metal oxide that is usually covered with a shell made up of organic or inorganic material or metal oxide. Metal NPs have diverse applications in our daily life. Many researchers and scientists reported research articles, and substantial development in this field, including the introduction of breakthrough methodologies for the production of metals, metal oxides NPs, and organic products [1].

The production of new compounds and applications has resulted from research into integrated approaches. During the past few decades, ultrasonic-assisted processes have intrigued the imagination of multidisciplinary scientists searching for more effective structures. Metallic nanoparticles or metal nanoparticles, a new terminology has been originated in the field of nanoparticles in recent few years. Noble metals like gold, silver, and platinum having beneficial effects on health are utilized for the synthesis of nanoparticles are designated as metallic nanoparticles.

In the past decades, nanomaterials have been widely applied in the fields of catalysis, microelectronic packaging, ceramics, and metallurgy [2-5]. Since the properties of nanomaterials are sensitive to the size and shape, it has become a key issue to control the size and morphology in the synthesis of nanomaterials. However, owing to their small particle size, nanomaterials can easily form aggregations or agglomerations, which may cause serious deterioration of their properties. In view of this, green synthesis treatment is introduced as an effective method to synthesize dispersed nanomaterials with fine particles or grains [6-8]. The selection of preparation method for the metallic nanoparticle is equally important because during nanoparticle synthesis processes such as kinetics of interaction of metal ions with reducing agent, adsorption process of stabilizing agent with metal nanoparticles, and various experimental techniques produce a strong influence on its morphology (structure and size) stability and physicochemical properties [9].

Metallic nanoparticle is nanosized metals with the size range of 10-100nm. Metallic nanoparticles have unique characteristics such as surface Plasmon resonance and optical properties. he optical properties of metal nanoparticles play a key role due to the localized surface Plasmon with resonance wavelength in the visible region [10-11].

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Many researchers around the world found that the ultrasonic pretreatment method has gradually attracted researchers' attention and can be considered an effective method to improve the surface properties and change the particle size distribution of coal [12]. A widely used high energy method to reduce the droplet size of nanoemulsions is ultrasonication because mechanical vibrations from ultrasound waves (> 20 kHz) create sinusoidal pressure variation in the emulsion system [13]. Hence, for reducing process nano size and shape, and energy during ultrasonication based nanomaterials production, this review article focuses on bridging particle size and ultrasonic treatment during the synthesis of metal nanoparticles.

This review article discusses the science behind metal nanoparticles and highlights the methods in their synthesis, characterization, as well as their potential (optical and electrical properties) applications. Also, an important part of green synthesis and applications of metal nanoparticles and future aspects.

RESULTS AND DISCUSSION

2.1 Properties of Metal Nanoparticles

2.1.1 Particle Size Analysis of Metal Nanoparticles

In recent nanotechnologies, the most versatile way of fabricating metal nanoparticles with well-defined structure is the utilization of colloid chemistry. Although the most well-known and stable structure of metal nanoparticles (NPs) is cubic close packing, diverse shapes can be obtained by adjusting experimental parameters by means of colloidal solution-based approaches.

The synthesis of metal nanoparticles majorly involves two different approaches named as top-down approach or dispersion method and bottom-up approach or condensation method. In top-down approach, the nanoparticles are formed by size reduction method where bulk materials are broken down into small materials [14].

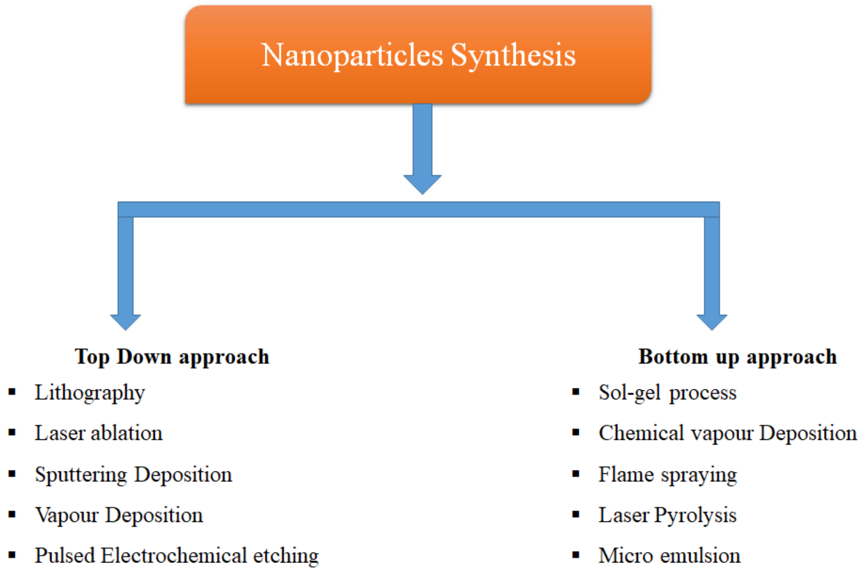

Figure 1: Schematic diagram representation of top-down and bottom-up and Various methods involved in the synthesis of nanoparticles.

2.1.2 Optical Properties of Metallic Nanoparticles

Optical properties of metallic nanoparticles are dependent on the specific particle, which means that further exploration of the different metals is required. Optical properties of nanomaterial such as absorption, transmission, reflection, and light emission are dynamic and may differ significantly from properties exhibited by the same bulk material. The optical property of nanomaterial is very important in a variety of ways. They are capable of confining their electrical properties to produce quantum effect with the possibility of the variation in shape, size, or type having effect on the color they produce. As the size increases, the color of the colloidal suspension of gold changes its color from red to yellow. Nanoparticles' color is due to the surface Plasmon resonance effect, which is a resonance of the outer electron bands of the particles with light wavelengths [15-17].

2.1.3 Electrical Properties of Metallic Nanoparticles

The properties like conductivity or resistivity come under the category of electrical properties. These properties are observed to change at the nanoscale level like optical properties. The examples of the change in electrical properties in nanomaterials are [18]:

1. Conductivity of bulk or large material does not depend upon dimensions like diameter or area of cross section and twist in the conducting wire etc. However, it is found that in the case of carbon nanotubes conductivity changes with a change in the area of cross-section.

2.) It is also observed that conductivity also changes when some shear force (in simple terms twist) is given to the nanotube.

3.) Conductivity of a multi-walled carbon nanotube is different than that of a single nanotube of the same dimensions.

2.2 Method of Preparation Metallic Nanoparticles

In general, mechanical ball milling and high-energy mechanical ball milling are effective physical methods for synthesizing nanoparticles and nanocomposites (e.g., metal–ceramic nanocomposites). Metallic nanoparticles were prepared using partial reduction ball milling technique. Bulk material is used as starting material in top-down methods and particle size is reduced to nanoparticles by different physical, chemical, and mechanical processes, whereas atoms or molecules are the starting material in bottom up methods shown in Figure 1 [19-22]. In top-down approach, the nanoparticles are formed by size reduction method where bulk materials are broken down into small materials. This can be accomplished with the use of ultrasonic generators of greater intensity operating at frequencies around 1,200,000 rpm [23]. In the bottom-up assembly, nanostructures are fabricated atom by atom or particle by the particle to build up the nanostructure. This can be attained by a high degree of super saturation followed by nuclei growth [24-25].

2.3 Green synthesis of metallic nanoparticles

'Green synthesis' are required to avoid the production of unwanted or harmful by-products through the build-up of reliable, sustainable, and eco-friendly synthesis procedures. The use of ideal solvent systems and natural resources (such as organic systems) is essential to achieve this goal. Green synthesis of metallic nanoparticles has been adopted to accommodate various biological materials [26]. Green synthesis of nanomaterials refers to the synthesis of different metal nanoparticles using bioactive agents such as plant materials, microorganisms, and various bio wastes including vegetable waste, fruit peel waste, eggshell, agricultural waste, and so on. The type of materials used in formulating the nanoparticles along with their particle size are the two most significant parameters, which can have an effect on the effectiveness of antimicrobial activity. It is well established that nanoparticles tend to possess different characteristics when compared to the same material having significantly greater dimensions. This is because the surface to volume ratio of the NPs considerably increases with a decrease in the particle size [27].

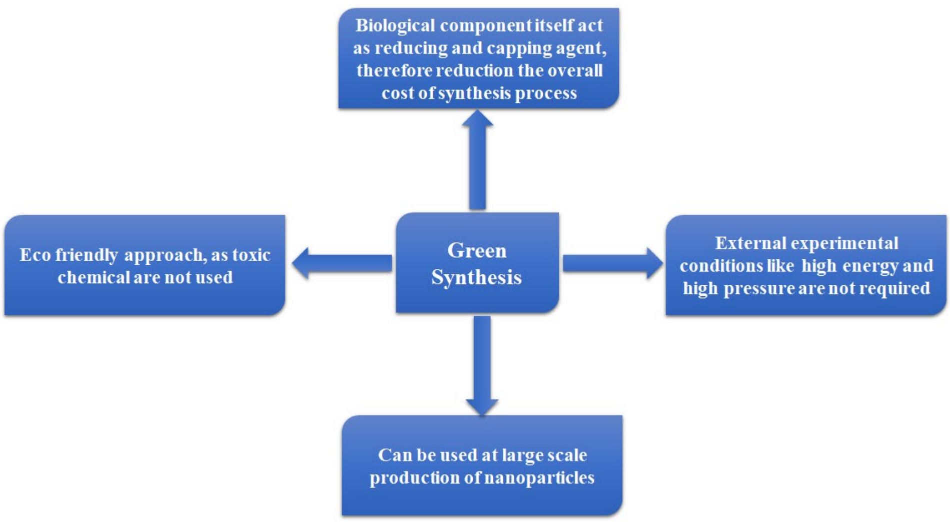

Figure 2: Flow chart of green synthesis of preparation metallic nanoparticles

2.4 Factors Affecting Metallic Nanoparticles Synthesis

There are many factors that influence the quality and quantity of synthesized nanoparticles for their potential use in various applications. Several factors such as the method used for synthesis, pH, temperature, pressure, time, particle size, pore size, environment, and proximity greatly influence the quality and quantity of the synthesized nanoparticles and their characterization and applications.

2.5 Advantages of the metallic nanoparticles

The advantages of metal-based nanoparticles, which are important for medical applications, include high biocompatibility, stability and the possibility of large-scale production avoiding organic solvents and thus giving a positive effect on biological systems. Synthesis of Metallic nanoparticles as a green chemistry approach compared with the conventional chemical techniques owing to several advantages such as eco-friendly nature, cost-effectiveness, multifunctionality, high scalability, and stability. Among all the metallic nanoparticles are extensively used in drug delivery because of several advantages: (i) ease of synthesis, characterization, and functionalization of the surface; (ii) ease of conjugation with drug molecules; (iii) slow and sustained release of drugs from the nanoparticles under physiological conditions; (iv) biocompatibility; and (v) long history of use in medicine [28-30].

2.6 Characterization technique, Properties, and Limitations of the metallic nanoparticles

Metallic nanoparticles and, green synthesis and their technological applications in various fields of science have become a topic of importance for the global research community. The selective and reproducible synthesis of metallic nanoparticles is imperative for wide applications. Various chemical and biological methods are used for the synthesis of metal nanoparticles.

Table 1: Characterization technique, Physical and Chemical Properties, advantage and limitations of metallic nanomaterials (NMs)

S.No	**Method**	Physical and Chemical Properties	Advantages	Limitations
1	**UV visible**	Optical properties, which depend on size and shape		
2	**FTIR**	Bio conjugate, Surface properties as structure and conformation	Minimal or no need for sample preparation demands	Sample preparation (IR) is complex intrusion and efficient absorbance of water
3	**XRD**	For crystalline materials, shape, size, and structure determination	Well-organized modalities. At atomic level, high spatial resolution	Usage in crystalline materials is reduced. Only one binding or conformation site for sample
4	**AFM**	Shape heterogeneity. Size and size navigation. Dispersion. Accumulation and sorption	Mapping of 3D sample surface resolution of subnanoscaled topographic samples	Lateral dimensions over description. Sampling is poor and time consuming
5	**SEM**	Size and size distribution. Shape. Aggregation.	Simultaneous measurement of the shape and size navigation of NMs	Constraint of conducting sample or coating conductive materials
6	**FESEM**	Dispersion	High resolution in natural status visualization of biomolecules supplied by the usage of FESEM technique	In nonphysiological states, the sample analysis occurs. Size distribution is based on subjective statistics.
7	**TEM**	Shape heterogeneity. Size and size navigation. Dispersion. Accumulation	For investigation of chemical composition and electronic structure of NMs. A lot of analytical techniques are paired with TEM	. Requirement of samples in nonphysiological states Variations or damage or in sample Sampling is insufficient Expensive equipment

Acronyms: UV-Visible (Ultra Violet Visible Spectroscopy); FTIR (Fourier Transform Infrared Spectroscopy); XRD (X-Ray Diffraction); AFM (Atomic Force Microscopy); SEM (Scanning Electron Microscopy); FESEM (Field Emission Scanning Electron Microscopy) and TEM (Transmission Electron Microscopy)

2.7 Future Prospect

Green synthesis technology presents a clean, non-toxic and ecofriendly technique for the synthesis of metallic nanoparticles. Improvement of reliable and eco-friendly processes for the synthesis of metallic nanoparticles is a significant step in the field of applied nanotechnology.

In the recent past, research on nanoparticles and their potential applications have progressed by leaps and bounds. Numerous studies have reported the green synthesis of metallic nanoparticles using various biological sources. A detailed toxicological study of the NPs on plants and animals is necessary for expanding its application in diverse fields. In addition to wild type strains, genetically modified microorganisms with the ability to produce greater quantity of enzymes, proteins, and biomolecules could further enhance the biosynthesis as well as the stabilization of NPs. Further, enhancement of metal accumulation capacity and tolerance of genetically modified microorganisms could provide a futuristic approach for the production and application of metal NPs using the green synthesis method.

CONCLUSIONS

The present review focuses on the green synthesis of metallic nanoparticles. Green synthesis methods provide a clean, non-toxic, and eco-friendly approach for the synthesis of metal NPs compared to other conventional techniques like physical and chemical methods. The size and shape of NPs and the reaction rate strongly depend on various experimental parameters such as reaction time, reactant concentration, pH, temperature, aeration, salt concentration. According to reviews of many research papers change to enhance the metal tolerance and accumulation capacity is the future approach to enhance the production of metal nanoparticles by adopting the “green synthesis” approach. The survey presented here has emphasized the importance of simple analytical theories for simple shapes. Characterization of nanomaterials is necessary to analyze the properties of nanomaterials. A discussion about the characterization of nanomaterials in detail is included in this review paper.

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