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Role of nanoparticle in different area of invention, Silver nanoparticle- formulation, mechanism and their implementation in research area.

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Abstract : Nanotechnology involves the study of materials having dimensional range 1 to 100 nm. When the concept of nanotechnology is applied in the medical field, the resulting outcome is known as 'Nanomedicine'. Nanomedicine generally includes nanoparticles, which are explored for various therapeutic applications. Various properties of nanoparticles like high reactivity, large surface area, and ultra small size make them highly efficient compared to conventional therapeutic agents. A recent technological advance that shows promise for applications in health care, including transplantation medicine, is the implementation of nanoparticles. Nanoparticles can be composed of a variety of organic or inorganic materials and confer many advantages over conventional treatments available, such as low toxicity, low-effective dosage required, and a high degree of manipulability. Although also used for imaging and diagnostics, nanoparticles' utility as a drug or genetic delivery system is of particular interest in transplantation medicine. Currently, researchers are exploring options to integrate nanoparticles into both diagnostics and therapy for both grafts ex-situ before transplantation and for patients following transplantation. These studies have demonstrated that nanoparticles can mitigate damage to organs and patients through a large variety of mechanisms—ranging from the induction of cellular genetic changes to the enhancement of immunosuppressive drug delivery. Specifically, with the advent of machine perfusion preservation ex vivo, treatment of the graft became a very attractive approach and nanoparticles have great potential. However, before nanoparticles can be translated into clinical use, their short-term and long-term toxicity must be thoroughly characterized, especially with regards to their interactions with other biological molecules present in the human body.

Key word- Nanoparticle, Nanotechnology, silver Nanoparticle, Method of synthesis.

I. Introduction:

A nanomaterial is defined as "an insoluble or biopersistant and intentionally manufactured material with one or more external dimensions, or an internal structure, on the scale from 1 nm to 100 nm" [1]. To date, nanotechnologies and nanomaterials have been extensively employed and the potential for growth in nanomedicine appears significant. Three principal fields of application are particularly targeted: diagnosis, drug administration, and regenerative medicine (2). The bright and fascinating colors of noble metal nanoparticles [3, 4] have attracted significant interest as a novel platform for nanobiotechnology and biomedicine [5, 6]. The applications of nanotechnology have broadened due to convenient surface bioconjugation with molecular probes and remarkable optical properties related with the localized plasmon resonance [7]. The frequency of the surface plasma resonance lies in the visible spectral range and depends on several factors like shape, size, dielectric properties of the particle environment, and interparticle interactions. This frequency also depends on the electron density in the metal and can be blue- or red-shifted depending on injection or withdrawal of electrons from the nanoparticles by varying the applied potential in an electrochemical environment [8- 9].

Nanotechnology is emerging as a rapidly growing field with its application in Science and Technology for the purpose of manufacturing new materials at the nanoscale level (10). The word "nano" is used to indicate one billionth of a meter or 10^{-9}. The term Nanotechnology was coined by Professor Norio Taniguchi of Tokyo Science University in the year 1974 to describe precision manufacturing of materials at the nanometer level (11). The concept of Nanotechnology was given by physicist Professor Richard P. Feynman in his lecture There's plenty of room at the Bottom (12).

Different types of nanomaterials like copper, zinc, titanium (13), magnesium, gold , alginate (14) and silver have come up but silver nanoparticles have proved to be most effective as it has good antimicrobial efficacy against bacteria, viruses and other eukaryotic micro-organisms (15). Silver nanoparticles used as drug disinfectant have some risks as the exposure to silver can cause agyrosis and argyria also; it is toxic to mammalian cells (15). The current investigation supports that use of silver ion or metallic silver as well as silver nanoparticles can be exploited in medicine for burn treatment, dental materials, coating stainless steel materials, textile fabrics, water treatment, sunscreen lotions, etc. and posses low toxicity to human cells, high thermal stability and low volatility (16).

A) PROPERTIES :

1.Properties and Structural Features of Nanosystems (Nanomaterials and Nanoparticles)

Nanosized systems are of a great interest mainly due to their exceptional surface-to-volume ratio and following distinctive optical, physical, and chemical properties, and to their increased bioavailability towards cells and tissues [17,18]. The nanosystems classically used in oral care cosmetics can be globally classified regarding their composition and structure. Nanosystem composition can be inorganic (metals, oxides, or calcium/phosphate (Ca/P) salts), organic (chitosan NPs) [19,20], phosphatidylcholin/cholesterol liposomes [21], or inorganic–organic hybrids (silica NPs encapsulated chlorhexidine (CHX); colloidal hexametaphosphate salt of CHX)). The nanostructured materials, often called nanomaterials, are defined as solid systems with nanodomains embedded in a large, dense matrix. Such structure must be distinguished from "free" NPs often synthesized as stable dispersed colloids. Both are used in oral care cosmetics that include either dense materials such as toothpaste, or liquid dispersed systems, such as mouthwash, for which ingredient stability during processing and ageing is a key point. The vertebrate bone, which is well known for its exceptional biocompatibility properties, is a perfect example of a natural nanostructured system with hydroxyapatite organized as nanocrystals embedded in collagen fibrils [22]. Please note that all oral care applications have so far been described, to our knowledge, by using only pure NPs, as they need an intermediate dense or liquid system to keep them from aggregation that reduces the benefit of the nanosized effect. The relative recent capacity to synthesize purified "free" NPs allows the design of new performing systems with innovative physico-chemical and bifunctional properties, along with biocompatibility.

NP morphology and size distribution may also be key factors for innovative oral care applications, as they are described as strategical parameters in other application fields dealing with nanometer-size particles [23-25]. Indeed, the expected nanometer-size effect on NP properties is generally claimed to be more efficient, since the size distribution is narrow, and the shape is homogeneous. Size distribution and shapes are highly associated with synthetic routes and chemical compositions of the NPs. For a unique NPs composition, various morphologies can be produced: nanospheres, nanorods, necklaces, nanoprisms, nanostars, or nanowires for the most common ones. Transmission or scanning electron microscopy, as well as scanning probe microscopy, are the tools of choice to analyze NPs following synthesis. Also, dynamic light-scattering can be used to characterize the average particle diameter and polydispersity index of aqueous NP dispersions. The stability of NPs, from synthesis to sterilization, storage processes, and use in biological environment, are also of interest regarding the availability to maintain nanosized distribution after synthesis and purification steps [26-29]. For example, consecutively to their synthesis and stabilization in a liquid environment, free drying or lyophilization, which is conventionally used to store NPs in a dried state, is well known to enhance more or fewer aggregation-irreversible mechanisms [30-33]. Then, the in situ characterization of NPs in the final product may be of great interest, as well as their characterization in the biological environment, where interaction takes place with the biological substances (proteins, membrane phospholipids, solid minerals (tooth, done), ions, pH, enzymes, etc.). Therefore, the relevant properties in the achieved products (toothpaste and mouthwash) are dependent mainly on the nanosized dimension [1,2,34-41]. However, to our knowledge, no studies have focused on NPs ageing or reorganization in relation to their stability in the oral care field. An important aspect to keep in mind when surveying the clinical application of NPs is the ageing of NPs between synthesis and their distribution in oral care products after incorporation within other ingredients. The evolution of size distribution by ageing of NPs, and the consecutive variation of their properties, is dependent on synthesis and purification protocols, as well as conditions of storage and the process of incorporation in the liquids or pastes. A prospective exploration of this point may be relevant for a complete understanding of the real impact of nanometer size of additive NPs on the final oral care product.

2. Effect of size and shape on the antimicrobial activity of Nanoparticles :

The surface plasmon resonance plays a major role in the determination of optical absorption spectra of metal nanoparticles, which shifts to a longer wavelength with increase in particle size. The size of the nanoparticle implies that it has a large surface area to come in contact with the bacterial cells and hence, it will have a higher percentage of interaction than bigger particles (42). The nanoparticles smaller than 10 nm interact with bacteria and produce electronic effects, which enhance the reactivity of nanoparticles. Thus, it is corroborated that the bactericidal effect of silver nanoparticles is size dependent (43). The antimicrobial efficacy of the nanoparticle depend on the shapes of the nanoparticles also, this can be confirmed by studying the inhibition of bacterial growth by differentially shaped nanoparticles (44).

B) TYPES OF NANOPARTICLE :

1) Polymeric Nanoparticle--

Polymeric nanoparticles (NPs) have attracted considerable interest over recent years due to their properties resulting from their small size . The polymeric nanoparticles (PNPs) are prepared from biocompatible and biodegradable polymers in size between 10-1000 nm where the drug is dissolved, entrapped, encapsulated or attached to a nanoparticle matrix. Depending upon the method of preparation nanoparticles, nanospheres or nanocapsules can be obtained (45).

Natural polymers: The most commonly used natural polymers in preparation of polymeric nanoparticles are

- Chitosan
- Gelatin
- Sodium alginate
- Albumin

There are many synthetic polymers like,

- Polylactides(PLA)
- Polyglycolides(PGA)
- Poly(lactide co-glycolides) (PLGA)
- Polyanhydrides.

Mechanisms of drug release:

The polymeric drug carriers deliver the drug at the tissue site by any one of the three general physico-chemical mechanisms.

1.By the swelling of the polymer nanoparticles by hydration followed by release through diffusion.

2.By an enzymatic reaction resulting in rupture or cleavage or degradation of the polymer at site of delivery, there by releasing the drug from the entrapped inner core.

3.Dissociation of the drug from the polymer and its de-adsorption/release from the swelled nanoparticles.(46)

2)Liposome:

Liposome was first discovered by Alec D. Bangham in 1961. Liposomes are spherical particles composed of one or more lipid and or phospholipid bilayers and contain spacing between the bilayers.

A great application of liposomes is that the structure can contain lipophilic as well as hydrophobic, and amphiphilic molecules, even more compounds with different solubility's can be incorporated in the spacing together (47).

Synthesis Techniques --

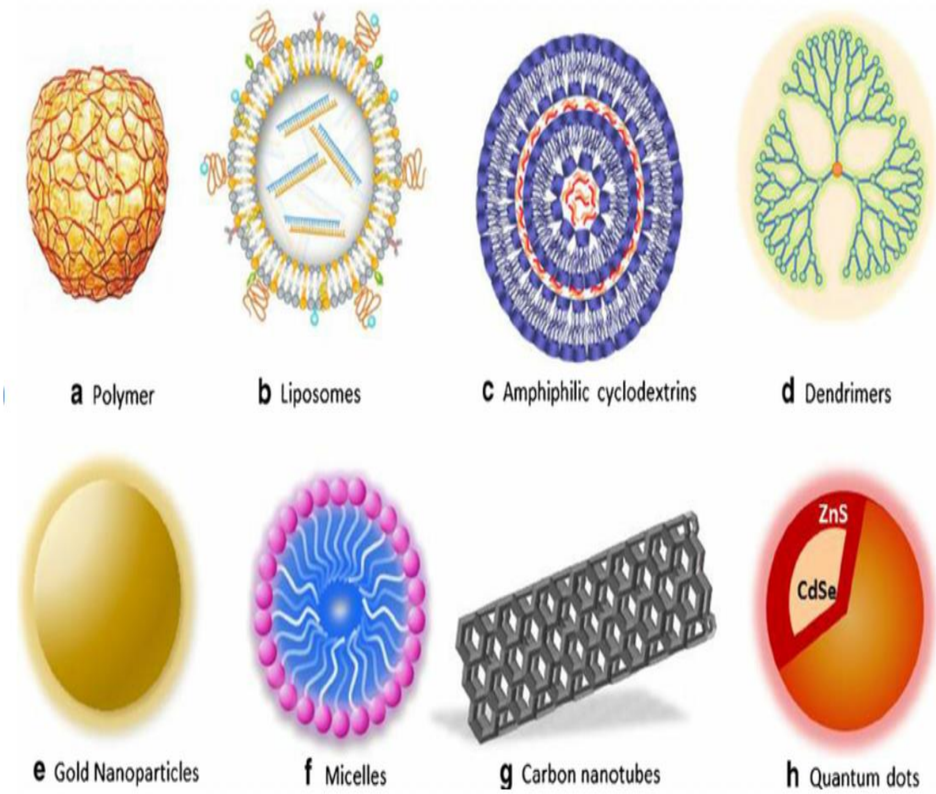
1) Extrusion Techniques,

2)Sonication.

a)Probe Sonication, b)Bath Sonication,

3)Microfluidizatio.

4)HeatingMethod.



Dig. Different types of nanoparticles commonly used for biomedical applications and which offer significant potential in delivering therapeutics across the blood- brain barrier.

3) Dendimer

Dendrimers are the highly branched molecules that combine the properties of polymers as well as small discrete entities. The structure of dendrimer can be up to 4 nm in diameter, but are usually within the 1-2 nm size range(48).

The total structure can further be divided into three structural components:

 The core, which is in higher generation dendrimers protected from the surroundings creating a dendrimer specific micro-environment.

 The outer shell, lies just below the surface and has a well-defined micro-environment.

 The multivalent surface, which has a high number of potential active sites.

4) Hydrogel --

Hydrogel nanoparticles have gained considerable attention in recent years as one of the most promising nanoparticulate drug delivery systems owing to their unique potentials via combining the characteristics of a hydrogel system (e.g., hydrophilicity and extremely high water content) with a nanoparticle (e.g., very small size). Several polymeric hydrogel nanoparticulate systems have been prepared and characterized in recent years, based on both natural and synthetic polymers, each with its own advantages and drawbacks. Among the natural polymers, chitosan and alginate have been studied extensively for preparation of hydrogel nanoparticles and from synthetic group, hydrogel nanoparticles based on poly (vinyl alcohol), poly (ethylene oxide), poly (ethyleneimine), poly (vinyl pyrrolidone), and poly-N-isopropylacrylamide have been reported with different characteristics and features with respect to drug delivery (49).

5) Inorganic nanoparticles : Past few years have seen a paradigm shift towards ecofriendly, green and biological fabrication of metal nanoparticles (MNPs) for diverse nanomedicinal applications especially in cancer nanotheranostics.

These microbial derived inorganic nanoparticles have been frequently evaluated as potential agents in cancer therapies revealing exciting results. Through, cellular and molecular pathways, these microbial derived nanoparticles are capable of killing the cancer cells (50).

1.Nanoparticles as Anti-Microbial and Anti-Inflammatory Agents in Oral Care Products :

In 2017, oral disorders affected 3.47 billion people in the world and represented one of the three most common causes of global diseases [51]. Among the oral diseases, the most prevalent were dental caries and periodontitis. Together, they represent the most common infectious human disease in the world [52]. Even if caries and periodontitis are multifactorial diseases, the main etiological factor is the presence of pathogenic bacteria. These bacteria are organized within an extracellular matrix to form a Nanomaterials 2020, 10, 140 4 of 32 bacterial biofilm [53]. In the biofilm, the bacteria are assembled to form a barrier that resists antibiotics and promotes chronic systemic infections [54]. Also, bacteria are 1000 times more resistant to anti-microbial treatment than planktonic organisms [55]. Moreover, in biofilms, bacteria can escape the immune system by producing superantigens [56]. To combat these bacterial infections, metal, metal oxide, and other NPs appear to be promising alternatives due to their distinct physio-chemical properties . Even if some materials have a naturally anti-bacterial activity, their anti-bacterial activity is increased when their dimensions are reduced to the nanometer regime. This is attributed to the physical structure of NPs and to the increased surface-to-volume ratio that permits them to interact and penetrate bacteria (57).

2.Nanoparticles as Remineralization Agents

To control the risk of caries and dental sensitivity of demineralized enamel, the action the remineralizing agents is required to restore structure and ensure enamel mechanical feature preservation. Indeed, the carious process corresponds to the demineralization of hard tissues in the tooth (enamel and dentine) due to attack from acids produced by bacteria from biofilms of dental plaque [57,58]. In the presence of fermentable carbohydrates, cariogenic bacteria grow and produce acid responsible for enamel demineralization [59,60]. To avoid caries, it is possible, as previously described, to fight against bacteria. However, another possibility is to favor the remineralization of tissues (Figure 1) [61]. Another major dental problem is dental erosion which corresponds to a progressive and irreversible loss of hard dental tissues due to a chemical process i.e., dissolution from acids not involving bacteria [62]. This can induce undesirable effects such as dental tissue loss, aesthetic defects, decreased vertical dimensions, and functional problems that may impact quality of life [63]. Moreover, the exposure of dentin, the internal tissue of the tooth, can lead to dental hypersensitivity. Hyperesthesia is related to the movement of fluids in dentinal tubules. It is characterized by an exaggerated reaction to a benign stimulus, unrelated to bacteria, and corresponds to a chronic pathology with acute episodes, specifically acute and brief pain [64]. Due to the fact that fluoride has demonstrated good properties of remineralization [64], few studies on NPs that have a remineralization effect have been undertaken. The main NPs known and used to remineralize are hydroxyapatite.

3. Cancer therapy :

It provides a unique approach and comprehensive technology against cancer through early diagnosis, prediction, prevention, personalized therapy and medicine. Target-specific drug therapy and methods for early diagnosis of pathologies are the priority research areas in which nanotechnology would play a vital part (65).

4. In agriculture :

A. In agriculture, nanotechnology is employed to increase food production, with equivalent or even higher nutritional value, quality and safety (66).

B. Controlled release of pesticides, herbicides and plant growth regulators can be achieved via the usage of nanocarriers. For instance, poly (epsilon-caprolactone) nanocapsules have been recently developed as herbicide carrier for atrazine. The treatment of mustard plants (Brassica juncea) with atrazine loaded poly (epsilon-caprolactone) nanocapsules enhanced the herbicidal activity compared to commercial atrazine (67).

C. Nanoscale carriers can be utilized to perfectly achieve the delivery and slow release of these species. Such strategies are known as “precision farming” that improves crop yields but not damage soil and water. Nanofertilizers are capable of reducing nutrient loss and enhancing nutrient incorporation by crops and soil microorganisms (68).

D.Nanofertilizers are capable of reducing nutrient loss and enhancing nutrient incorporation by crops and soil microorganisms (69).

E.Commercialized nanofertilizers are mainly the micro-nutrients at nanoscale (e.g., Mn, Cu, Fe, Zn, Mo, N, B, see Table 2). It is noted that the use of other nanomaterials (instead of the typical conventional crop fertilizers), such as carbon nano-onions (70).

F. A recent report showed that copper doped montmorillonite can be used for on-line monitoring of propineb fungicide in aquatic environment (both in fresh and salty water), with a low detection limit of about 1 μM (71).

G. Another study showed that nanomaterials like graphene can be developed to detect pathogen in wastewater (72).

5. In food industry

Food nanotechnology has infiltrated into many aspects of customer products, such as food packaging, additives, and food preservation (73).

5.1. Food processing

A. Nanomaterials are well designed as color or flavor additives, preservatives, or carriers for food supplement (i.e. nanoencapsulation and nanoemulsion), including animal feed products. The unique properties of engineered nanomaterials offer great advantages for food processing as ingredients or supplement. Additionally, inorganic oxide chemicals such as SiO_2 (E551), MgO (E530), and TiO_2 (E171) are permitted by the U.S. FDA as anti-caking agent, food flavor carrier, and food color additives (see Table 1). For instance, TiO_2 is widely used as additive in foods such as gum, white sauces, cake icing, candy and puddings (74)

The direct contact of nanomaterials used as food additives/functional/nutritional ingredients may pose threats to human health. The production of reactive oxidative species (ROS) acts as one of the main toxicological mechanisms causing cellular damage and death (75).

5.2. Data generating and analysis:

current methodologies typically used for toxicology provide little information that is useful for chemists to improve their sustainable design for large scale use.

5.3. food packaging:

A. Among many novel nanomaterials, nanoclay is one of the most widely used and studied for food packaging due to their mechanical, thermal, and barrier properties, and low cost. For instance, 1 wt % bentonite clay/poly (vinyl alcohol) loaded nanocomposite membrane significantly enhanced permeance with a water permeance of 6500 gpu and a selectivity value of 46 . (76)

B. Coated fresh food products such as vegetables and fruits remain active during transportation and storage processes. The active respiration processes may cause significant postharvest losses and poor quality cosmetically and nutritionally in products as the transportation and storage time extends. The control over such weight and nutrition loss is paramount to extend shelf life of fresh food products. Relative humidity and temperature are of the utmost concerns. They act together to alter fresh food respiration, as well as the microbial activities in the products (77).

6.Toxicological fundamentals and risk assessment

A. Exposure routes and interactions

a. The increasing application of nanotechnology in the food and agriculture sectors has attracted public attentions over the past decade. Nanomaterials are either intentionally added as food additives or unintentionally introduced via migration (78). Assessment of the migration potential of nanosilver from nanoparticle-coated low-density polyethylene food packaging into food stimulants.

b .Although holistic approach has been recommended for understanding of the nano-bio-eco interactions between the nanomaterials and biotic and abiotic environments in a connected ecosystem (79).

Using a holistic approach to assess the impact of engineered nanomaterials inducing toxicity in aquatic systems.

C. Particle agglomeration may occur any time during the digestions process, but mostly significantly in stomach fluid. In intestinal fluid, agglomerates tend to deagglomerate into primary particles. In addition, nanoparticulate structures are formed de novo from free ions (80).

SYNTHESIS METHOD OF NANOPRTICLE :

1) Co- Precipitation :- Synthesis and Characterization of Uniform and Crystalline Magnetite Nanoparticles via Oxidation-precipitation and Modified co-precipitation Methods.

Nanoscaled magnetite (Fe_3O_4) is a kind of magnetic functional nanomaterial, and it has cubic inverse spinel structure with oxygen forming a fcc closed packing and Fe cations occupying interstitial tetrahedral sites and octahedral sites. The electrons can hop between Fe^{2+} and Fe^{3+} ions in the octahedral sites at room temperature; therefore, it is an important class of spintronics material [81].

2) Ultrasound-driven oxidation and self-assembly of amino acids into nanoparticles:

Acoustic cavitation in aqueous solutions containing small aromatic amphiphilic molecules can cause a series of reactions, without the addition of any external reagents, and lead to the generation of reactive radical species to initiate hydroxylation, oligomerization, and self-assembling processes. These processes can take place in bulk water phase or at air–liquid interface to form high molecular weight products, i.e., dimers, oligomers. Cavalieri31 (82).

3)Hydrothermal Synthesis of Nanomaterials :

Hydrothermal synthesis is one of the most commonly used methods for preparation of nanomaterial. It is basically a solution reaction-based approach. In hydrothermal synthe-sis, the formation of nanomaterials can happen in a wide temperature range from room temperature to very high tem-peratures. To control the morphology of the materials to be prepared, either low-pressure or high-pressure conditions can be used depending on the vapor pressure of the main com-position in the reaction. Many types of nanomaterials havebeen successfully synthesized by the use of this approach. There are significant advantages of hydrothermal synthesis method over others. Hydrothermal synthesis can generate nanomaterials which are not stable at elevated temperatures. Nanomaterials with high vapor pressures can be produced by the hydrothermal method with minimum loss of materials (83).

4) Microwave :

The microwave synthesis, superparamagnetic iron oxide nanoparticles can be synthesised with a small diameter, a good monodispersity and stability in an aqueous solution. These nanoparticles can be used for the biomedical applications with a dispersion in ultra-pure water and in physiological conditions. In this work, for the first time, this synthesis method of SPIONs is performed in ultra-pure water with a validate redispersion in physiological serum (84).

5) Sol - gel Method :

Ever increasing solid waste is now becoming a challenge for a sustainable world. Improper management of those wastes leads to public health and environment related problems (85).

D. MECHANISM OF ACTION :

The exact mechanism of action of silver on the microbes is still not known but the possible mechanism of action of metallic silver, silver ions and silver nanoparticles have been suggested according to the morphological and structural changes found in the bacterial cells.

1. Mechanism of action of silver :

The mechanismof action of silver is linked with its interaction with thiol group compounds found in the respiratory enzymes of bacterial cells. Silver binds to the bacterial cell wall and cell membrane and inhibits the respiration process (Klasen, 2000). In case of E. coli, silver acts by inhibiting the uptake of phosphate and releasing phosphate, mannitol, succinate, proline and glutamine from E. coli cells (86).

2. Mechanism of action of silver ions/AgNO3:

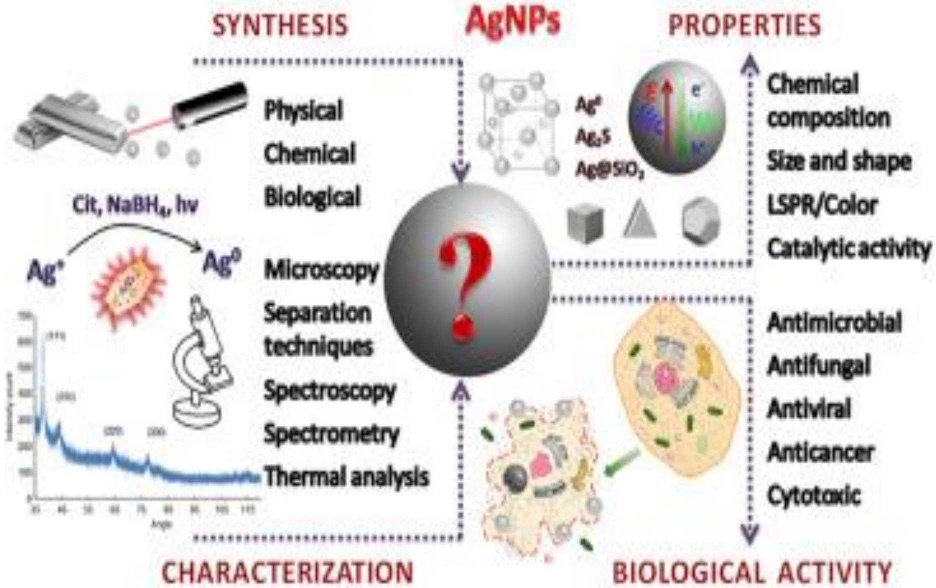
The mechanism for the antimicrobial action of silver ions is not properly understood however, the effect of silver ions on bacteria can be observed by the structural and morphological changes. It is suggested that when DNA molecules are in relaxed state the replication of DNA can be effectively conducted. But when he DNA is in condensed form it loses its replication ability hence, when the silver ions penetrate inside the bacterial cell the DNA molecule turns into condensed form and loses its replication ability leading to cell death. Also, it has been reported that heavy metals react with proteins by getting attached with the thiol group and the proteins get inactivated (87).

3. Mechanism of action of silver zeolite :

Silver ions play a crucial role in the antibacterial activity of silver zeolite. Matsumura et al. (2003) reported that the possible action of silver zeolite might be due to the intake of silver ions by bacterial cells when they come in contact with silver zeolite, which inhibits their cellular functions and damages the cell. Secondly, it can be due to the generation of reactive oxygen molecules, which inhibit the respiration.

4. Mechanism of action of silver nanoparticles:

The silver nanoparticles show efficient antimicrobial property compared to other salts due to their extremely large surface area, which provides better contact with microorganisms. The nanoparticles get attached to the cell membrane and also penetrate inside the bacteria. The bacterial membrane contains sulfur-containing proteins and the silver nanoparticles interact with these proteins in the cell as well as with the phosphorus containing compounds like DNA. When silver nanoparticles enter the bacterial cell it forms a low molecular weight region in the center of the bacteria to which the bacteria conglomerates thus, protecting the DNA from the silver ions. The nanoparticles preferably attack the respiratory chain, cell division finally leading to cell death. The nanoparticles release silver ions in the bacterial cells, which enhance their bactericidal activity (88).



Dig: Silver Nanoparticle- synthesis and characteristics.

E. PROPERTIES OF SILVER NANOPARTICLE :

Silver is a metal known for its broad spectrum antimicrobial activity against Gram-positive and Gram-negative bacteria, fungi, protozoa and certain viruses. The persistence of antibiotic-resistant bacteria has exploited the anti microbial properties of silver and silver-based compounds, including silver nanoparticles [30].

1. Nano silver as a potent bactericidal agent:

Understanding the antibacterial mechanism of designed nanoparticles is important for achieving the synergistic effects with biomolecules. In general the mechanism of cellular toxicity exhibited by metal nanoparticles is through the release of reactive oxygen species (ROS) [58]. The anti bacterial properties of silver nanoparticles are associated with its slow oxidation and liberation of Ag+ ions to the environment making it an ideal biocidal agent. Moreover, the small size of these particles facilitates the penetration of these particles through cell membranes to affect intracellular processes from inside. Additionally, the excellent antibacterial properties exhibited by the nanoparticles are due to their well developed surface which provides maximum contact with the environment [29]. A better understanding of the bactericidal action of nanosilver would require a proper examination of the membrane-bound and intracellular nanoparticles. Silver nanoparticles were found to penetrate into the bacterial cell causing membrane damage and ultimately the death of the organism. For example, Duran et al. reported the potential antibacterial activities of silver nanoparticles synthesized using Fusarium oxysporum [29]. The antibacterial properties exhibited by nano silver can be extended to the textile industry as well [20]. The nanoparticles synthesized using bio-based approaches were found to have excellent antibacterial properties over Escherichia coli when impregnated on cotton disks [18]. There are reports, which have discussed about the synthesis of metal nanoparticle embedded paints using vegetable oils in lieu of their excellent antibacterial properties [31].

2. Nano silver in anti fungal therapy:

Fungal infections havebecome more common in the recent years and silver nanoparticles have emerged itself in use as potential anti fungal agents. In particular, fungal infections are most commonly found in immune compromised patients because of cancer chemotherapy or human immunodeficiency viral infections [32]. There are many reports showing the anti microbial effects of silver nanoparticles but the anti fungal effects of silver nanoparticles remain unexplored. According to the reports of Kim et al., silver nanoparticles exhibited excellent anti fungal activity on Candida albicans by disrupting the cell membrane and inhibiting the normal budding process [59]. In order to compare the anti fungal effects of silver nanoparticles, amphotericin B, an antifungal agent used to treat serious systemic infections was used as a positive control [60]. Silver nanoparticles showed remarkable antifungal activity against Trichophyton mentagrophytes and Candida species. Remarkably, these particles exhibited similar activity with amphotericin B, but more potent activity than fluconazole toward all the fungal strains examined.

3. Anti inflammatory effects of nano silver:

There is an urgent need for the development of new inflammatory drugs as most of the inflammatory diseases are not responsive to the available drugs. The challenge for the development of efficient anti-inflammatory drugs lies in finding appropriate targets that are mostly dispensable for host defense against pathogens. The discovery of potent drugs is expected to revolutionize the treatment of several inflammatory diseases. Nanocrystalline silver dressings had wound healing properties by virtue of its size and it is used as commercial antimicrobial dressings since 1998 [61,62].

4. Antimicrobial activity of Ag nanoparticles against microorganisms:

The mechanism of the growth-inhibitory effects of Ag nanoparticles on microorganisms has not been well understood. One possibility is that the growth inhibition may be related to the formation of free radicals from the surface of Ag. Uncontrolled generation of free radicals can attack membrane lipids and then lead to a breakdown of membrane function [65].

5. Antioxidant effect of Ag nanoparticles and silver nitrate in antimicrobial activity :

To determine the relationship between free-radical and antimicrobial activity, we used the antioxidant NAC to test whether the antioxidant could influence antimicrobial activity induced by Ag nanoparticles. Ag nanoparticles and silver nitrate showed similar growthinhibitory effect against E. coli. However, such inhibitory effect was abolished by the addition of NAC. NAC alone did not affect the antimicrobial activity.

CONCLUSION:

We hereby provide glimpse of a rapidly emerging research area that is located at the crossroads of materials research, nanosciences, and molecular biotechnology. The nanomaterials exhibit great prospects in biomedical applications since their dimensions match those of biological molecules and entities. The surface modified silver nanoparticles have proved to have improved biocompatibility and intracellular uptake for drug delivery and other biomedical applications. The nano bioconjugates of silver in particular have also proved its role as efficient bionalyzers for the detection of various analytes in solution. This review creates an insight into the efforts and approaches for the bio functionalization of silver nanoparticles. The excellent optoelectronic and plasmonic properties of silver nanoparticles have brought them to the forefront of nanotechnology research directed toward applications ranging from sensing to biomedical applications. The first section gives an overview of the synthesis and applications of silver nanoparticles and the need for modifying the surface of these particles. Although any number of biomolecules can be coupled to nanoparticles by means of various methods, there is still a great demand for mild and selective coupling techniques for the preparation of thermodynamically stable and well-defined bioconjugate hybrid nanoparticles.

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