Austin Journal of Nanomedicine & Nanotechnology

Open Access

Austin Publishing Group

Review Article

Nanotechnology; A Great Innovation in Scientific Research and Technology-A Review

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Received: February 05, 2019; **Accepted:** March 12, 2019; **Published:** March 19, 2019

Abstract

Nanotechnology has brought numerous scientific development in the area of research and expertise. Nanoparticle is a core particle which performs as a whole unit in terms of transport and property. Nano size particles are quite unique in nature because nano size increase surface to volume ratio and also its physical, chemical and biological properties are different from bulk material. So the main aim to study its minute size is to trigger chemical activity with distinct crystallography that increases the surface area. Nanotechnology represents the design, production and application of materials at atomic, molecular and macromolecular scales, in order to produce new nano-sized materials. The synthesis of Nanoparticles mainly done by several different chemical, physical and biological methods. Each method has its own significance and Nanoparticles synthesized by a specific method are utilized in a specific field. On characterization, it is concluded that Nanoparticles are the best advanced materials to apply in almost every field of research and technology for routine life applications. Nanoparticles are applied now a day in medical fields for diagnosis of diseases, and their cure. These are applied in electronic industries to make nano-chips and microchips. Along with, there are used in health and dispensary, power industry and environment safety, farming, armed forces and other productions. Thus, this review explores the scope, synthesis, characterization, and applications of Nanoparticles in fields of research and technology.

Keywords: Nanotechnology; Nanoparticles; Laser ablation; Solvo-thermal; Sol-gel; Computational nanotechnology

Abbreviations

NPs: Nanoparticles; SEM: Scanning Electron Microscopy; TEM: Transmission Electron Microscopy; AFM: Atomic Force Microscopy; DLS: Dynamic Light Scattering

Introduction

In recent years, nanotechnology has brought countless scientific development in the area of research and expertise. Nanotechnology is the study and application of minor objects that can be applied thoroughly in all scientific areas of research such as chemistry, biology, physics, material science and Engineering. Nanoparticle (NPs) is a core particle, which performs as a whole unit in terms of transport and property [1]. As the name indicates nano means a billionth or 10-9 unit. Its size range usually from 1-100nm due to small size it occupies a position in various fields of nano science and nanotechnology. Nano size particles are quite unique in nature because nano size increase surface to volume ratio and also its physical, chemical and biological properties are different from bulk material. So the main aim to study its minute size is to trigger chemical activity with distinct crystallography that increases the surface area [2]. Thus in recent years much research is going on metallic nanoparticle and its properties like catalyst, sensing to optics, antibacterial activity and data storage capacity.

Although often referred to as the ‘tiny science’, nanotechnology does not simply mean very small structures and products [3]. Nanoscale features are often incorporated into bulk materials and large surfaces. Nanotechnology represents the design, production and application of materials at atomic, molecular and macromolecular scales, in order to produce new nano-sized materials [4].

The concept of nanotechnology emerged on 9th century. For the first time in 1959, Richard Feynman gave a talk on the concept of nanotechnology and described about molecular machines built with atomic precision where he discussed about NPs and entitled that “There’s plenty of space at the bottom” [5]. The term “nanotechnology” first time used as scientific field by Nario Tanigushi (1974) in his paper was “Nanotechnology”. It mainly consists of the processing, separation, consolidation, and deformation of materials by one atom or one molecule [6].

Nanotechnology is the science of the small; the very small. It is the use and manipulation of matter at a tiny scale. At this size, atoms and molecules work differently, and provide a variety of surprising and interesting uses. Nanotechnology and Nanoscience studies have emerged rapidly during the past years in a broad range of product domains. It provides opportunities for the development of materials [7]. Nanotechnology is a scientific discipline involving classical scientific fields, such as physics, quantum mechanics, chemistry, biochemistry, electronics etc., in development of materials, equipment and functional systems with exceptional properties, ensuing from the quantum principle and ability of self-organizing of mass in nanometer dimensions. At present there are many definitions of nanotechnology, which differ more or less [8,9]. Nanotechnology involves research and technological development on atomic, molecular or macromolecular

Citation: Fazal-ur-Rehman M, Qayyum I and Rehman R. Nanotechnology; A Great Innovation in Scientific Research and Technology-A Review. Austin J Nanomed Nanotechnol. 2019; 7(1): 1051.

levels, on a dimensional scale approximately from 1 to 100 nm [10].

Nanotechnology is an innovation of modern fundamental science. It is a very complicated professional area, uniting the efforts of professionally qualified chemists, physicists, mathematicians, materials scientists, physicians, computer scientists, and so on. At the present stage, nanoparticle research is an intense scientific research due to its wide potential application in biomedical, optical and electronic fields [11]. NPs are a narrow bridge in between bulk materials and molecular (atomic) structures. Bulk materials have constant physical properties [12] because they have grain structures with random grains individually oriented in space and contacting each other across grain boundaries but nano-materials are made up of a single grain with all the atoms oriented in a crystalline lattice [13].

The main characteristics of nanomaterials that distinguish them from bulk materials are (1) large fraction of surface atoms; (2) high surface energy; (3) spatial confinement; (4) reduced numbers of imperfections that do not exist in the corresponding bulk materials [14]. NPs show different properties such as quantum confinement, Surface Plasma Resonance (SRP), decrease in melting temperature which are directly related to the crystal lattice of the nanomaterials. The use of Nanomaterials provides the following advantages, Firstly, as nanomaterials consist of very small particles they, promote accomplishment of super miniaturization and thus the nanostructures can be packed very closely together which can be useful for Nano electronics. Secondly, because of their small dimensions, nanomaterials have large specific surface areas which increase the interactions between them and the environment in which they are located. Nanotechnology should not be viewed as a single technique that only affects specific areas [1].

Types of Nanotechnology

Nanotechnology is a fast growing area in the field on science, which is an interdisciplinary field of both science and technology that increase the scope of investing and regulating at cell level between synthetic material and biological system. Nanotechnology proceeds by three processes; separation, consolidation, deformation of material by one atom or molecule.

It is divided into three types; Wet nanotechnology which deals with the biological system such as enzymes, membrane, cellular components. Dry nanotechnology deals with the surface science, physical chemistry & gives importance on fabrication of structure in carbon, silicon, inorganic materials [15,16]. Computational nanotechnology which deals with modeling & stimulating the complex nanometer scale structure, these three fields are interdependent to each other [17].

Classification of NPs

NPs can be broadly classified into two groups: Organic NPs and Inorganic NPs [18]. Organic NPs are carbon nanoparticle (fullerenes) and inorganic NPs are magnetic nanoparticle, noble nanoparticle (gold and silver), semiconductor nanoparticle (titanium oxide and zinc oxide). Especially inorganic NPs have created attention towards itself due to its superior material properties with versatile functions. Due to nano size feature it easily used for chemical imaging drugs agents and drug. Its versatile function used for the cellular delivery as they are widely available, rich functionality, good biocompatibility [19]. This is also a good carrier of targeted drug delivery and controlled drug release. it is a completely advantageous material for medical science. For example, mesoporous silica combined with molecular medicines shows an excellent image on drug releasing [20]. Synthesis of nanoparticle gets concern in nanotechnology due to the variable size, shapes, chemical composition and controlled dispersity and their potential use in the medical science for the better treatment of human benefits.

Synthesis of NPs

There are two approaches of synthesis of metallic NPs which are chemical approach and physical approach (Figure 7) [21]. In chemical approach it includes chemical reduction, electrochemical technique, and photochemical reduction [22]. The chemical process is again subdivided into classical chemical method where some chemical reducing agents (hydrazine, sodium borohydride, hydrogen) are used. While radiation chemical method generated through ionization radiation. In physical approach, it comprises of three steps which are condensation, evaporation and laser ablation for metal nanoparticle synthesis [23]. Biological synthesis of NPs which is an inspiring concept, also very well-known as green synthesis. The biological synthesis of NPs can resolve the environmental hazards which are solar energy maintenance, farming production, catalysis, electronic, optics, and Biotechnological area. Green synthesis of NPs is total effective, certainly accessible, ecological, non-hazardous, bulky manufacturing and act as reducing and coating agent in compared to chemical method which is a very expensive and also it emits dangerous by-products which can have several injurious effect on our environment [24].

Biological synthesis uses the logically occupying reducing agent like plant extract, micro-organisms, enzymes, polysaccharides which are common and worthwhile and also the alternate solution to other complex and poisonous chemical methods [25]. Plants can be defined as nano factories because they offer prospective way to bio-accumulation into food chain and environment. Among several biotic agents, plants offer nonviolent and valuable means to the synthesis of metallic NPs as it is simply accessible so there are prospects for bulk production separately from this synthesis route is ecological, and its ratio of production is faster in comparison to other biotic methods such as microbes, algae and mushrooms [26]. From other several literature studies, it can be specified that quantity of accumulation of NPs differs with reduction potential of ions and reducing capability of plant depends on manifestation of several polyphenols and further heterocycles.

Traditional Synthesis of NPs

Traditionally, scientists mostly used two approaches for the synthesis NPs such as Bottum-up and Top-down approaches (Figure 5), detailed below.

Bottom-up approach: The bottom-up approach (Figure 1) is a nano-architectural method of self-assembly of materials from cluster-to-cluster, molecule-to- molecule or atom-to-atom at the top of base substrate [27]. The most important fact in bottom-up approach is the adhesion of surface films to base substrate. The most commonly used bottom- up methods is wielding & riveting.

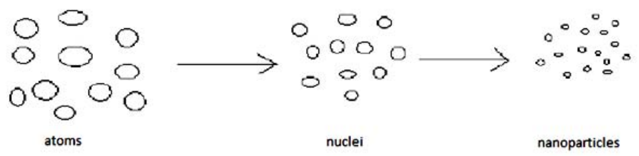

Figure 1: Bottom-up Approach for synthesis of NPs.

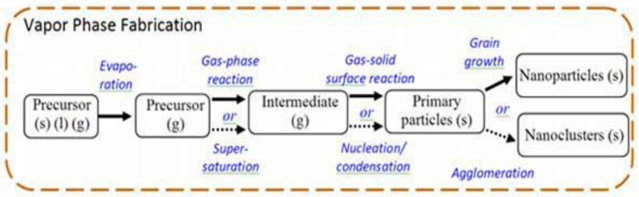

Figure 2: Vapor Phase Fabrication for synthesis of NPs.

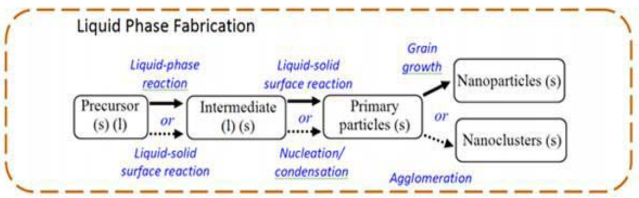

Figure 3: Liquid Phase Fabrication for synthesis of NPs.

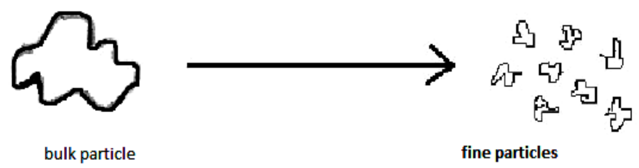

Figure 4: Top down Approach for synthesis of NPs.

These are further classified according to phases:

Gas (Vapor) phase fabrication: Pyrolysis, Inert Gas Condensation (Figure 2).

Liquid phase fabrication: Solvo-thermal Reaction, Sol-gel, Micellar Structured Media (Figure 3).

Top down approach: The Top down method (Figure 4) refers to a set of fabrication technologies starting with a block bulk material, which share the same material with the base substrate [28]. The most commonly used top down methods are milling, drilling and grinding.

Physical approach

In the physical approach, metal NPs are manufactured by any of both methods which are evaporation condensation method and laser-ablation method [29]. In the evaporation condensation method, reaction is done by means of a tube furnace at atmospheric pressure. The target material is subjected within a boat aligned at furnace, and vaporized in-to a carrier gas. But this method has some disadvantages, such as tube furnace occupies a large space, consumes a great deal of energy raising the surrounding temperature around the source material and needs a lot of time to attain thermal stability. The particles synthesized through laser ablation method depends upon

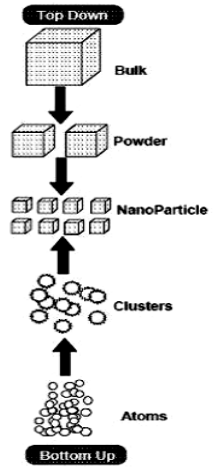

Figure 5: Bottom-up and top-down Approaches.

wavelength of laser, duration of the laser pulses the laser flounce, ablation time duration and effective liquid medium which may or may not having the surfactant.

Chemical approach

Chemical method is a most commonly used technique for production of silver NPs. The most commonly used reducing agents are sodium borohydride, hydrazine hydrate, potassium auro chlorate and sodium citrate [30]. The reduction of several complexes with Ag+-ions leads to the creation of silver metal atoms (Ago), which is monitored by agglomeration into oligomeric clusters. These clusters ultimately lead to the creation of colloidal Ag particles. The purpose of the protective agent is to protect NPs from accumulation in cluster. The most commonly used protecting agents are Polyvinyl Pyrolidone (PVP), Polyethylene Glycol (PEG), Polymethacrylic Acid (PMAA) and Polymethylmethacrylate (PMMA) [31].

Liquid phase synthesis methods

The liquid phase fabrication involves a wet chemistry method. There are two approaches in liquid phase synthesis of NPs which are; Sol-Gel Approaches and Solvothermal Approaches (e.g. hydrothermal).

Sol- gel Approaches is applied for the synthesis of metal NPs (metal oxides) from a chemical solution which acts as a precursor for incorporated network of distinct units or polymers (Figure 6) [32]. The precursor solution can either be dumped on the substrate to form a film cast into a proper container having preferred shape or can be utilized to synthesize the powders.

Solvothermal Approaches is a malleable low temperature method in which polar solvents under pressure and at temperatures above their boiling points are used. The reaction of the reagents under the solvothermal conditions increases significantly and enabling the reaction to take place at lower temperature [33].

Biosynthesis of NPs

Although, both chemical and physical approaches are very effective to synthesize the distinct NPs, they have definite restrictions such as increase charge of assembly, release of dangerous by-products,

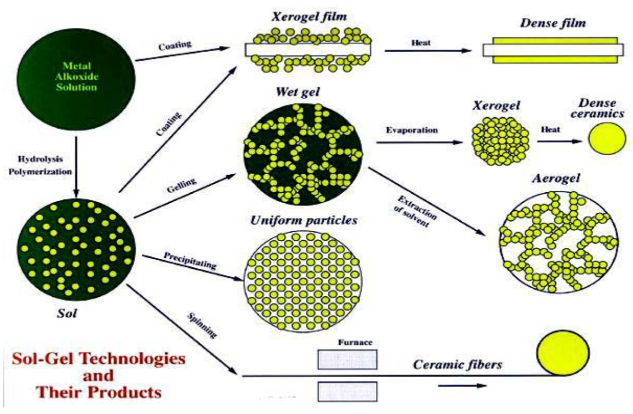

Figure 6: Sol-gel Method.

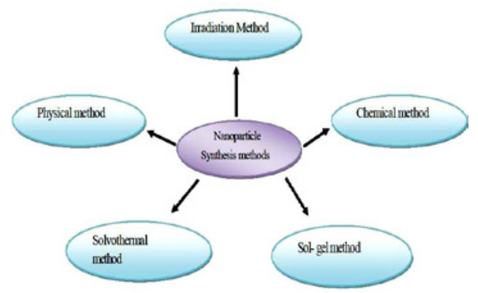

Figure 7: Various methods for Nanoparticle synthesis.

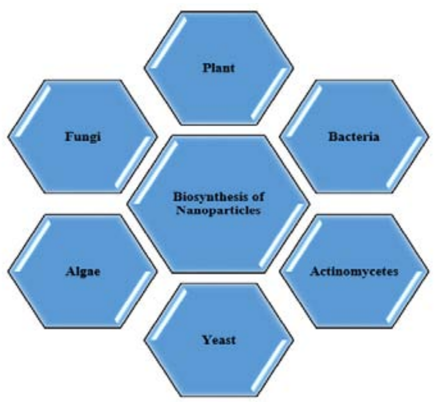

Figure 8: Biosynthesis of NPs by different routes.

long time for production and striving in purification. Global warming and environment change has convinced a universal consciousness to diminish the toxic and lethal waste by-products, thus, its green synthesis method has elevated dynamically the advancement in fields of science and industry. Biosynthesis of NPs (Figure 8) as name specifies the help in synthesis of very complex reaction within a fraction of minutes have now taken up the consideration towards production protest the requirement of ecologically benevolent technologies in material sciences [34]. Implementation of biological organisms (microorganism, plant extracts, biomass etc.) can be a best alternate technique of physical and chemical technique for production of NPs because the biological synthesis method is very spontaneous, commercial, eco-friendly and harmless [35]. Thus, biological sources (bacteria, fungi, yeasts, algae and plants etc.) can catalyze the specific reaction as a part of modern and realistic biosynthetic approach [36].

The current future on biological system has been created a commercial importance due to their enzymatic reactions, photochemical characteristics and herbal nature. Biological system has created a specific and revolutionary change for synthesis of NPs due to their mode of mechanism through which bio-reduction of metallic salts occurs is still a mystery [37]. Various research studies have been done on production of NPs from biological system of for their uses in field of biomedical, pharmaceutical, cosmetic and environmental sciences. Bio-fabricated NPs can be used for bioremediation purposes because NPs can penetrate *via* contaminants and cause a redox reaction to clean surface materials.

Nature has some managed scheme to synthesis of nano and micro sized materials, which contribute to development of relatively new and unexplored areas of research and technology based on biosynthesis of nanomaterials.

Bacteria: Numerous microorganisms can produce inorganic NPs like silver, gold, magnesium, cadmium sulphide, and silicon oxide NPs [38]. The resistance caused by the bacterial cell for silver ions in the environment is responsible for its NPs synthesis.

Fungi: Fungi can yield higher quantities of NPs in contrast to bacteria because they can discharge higher quantities of proteins which directly decode to higher yield of NPs. Fungi can be defined as best nano-factories in relation to bacteria because they have high binding capability with metal ions in intracellular area, they are easy to isolate on solid substrate fermentation, they can develop on surface of inorganic substrate in isolation leading to effective distribution of metals as catalyst [39]. The advantage of fabrication of NPs extracellularly from fungi is that a huge amount of enzymes which are in pure form and are free from their cellular protein, can be easy to apply for simple downstream route.

Actinomycetes: Actinomycetes are micro-organisms that have some of important characteristics of both bacteria and fungi. Due to their capability to yield minor metabolites such as antibiotics, actinomycetes are now gaining the attention for production of metallic NPs.

Algae: Algae are a miscellaneous cluster in plant kingdom that are being explored for their application in nanotechnology.

Plants: Several micro-organisms (bacteria, algae, fungi and yeasts etc.) are utilized for biological synthesis of NPs but recently, a new trend has come to force (i.e., use of plants) for the manufacture of NPs because of its spontaneous, inexpensive, ecological protocol, suitable for great scale manufacture and is a single step method for biological route of synthesis of NPs [40]. The key mechanism, reflected for manufacture of NPs refereed by plants, is due to presence of phyto-chemicals. The key phyto-chemicals accountable for spontaneous reduction of the ions are; terpenoids, flavonoids, quinones, carboxylic acids, ketones, aldehydes and amides.

Characterization of NPs

NPs are normally characterized through their size, surface charge, and morphology, by means of advanced microscopic methods (Figure 9) as Scanning Electron Microscopy (SEM), Transmission Electron

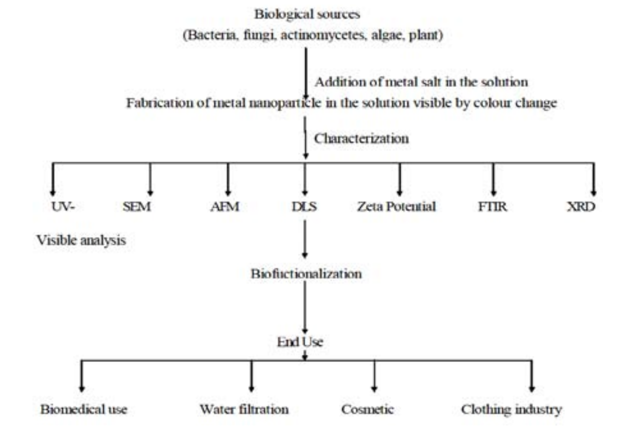

Figure 9: Flow chart for the synthesis & characterization of NPs.

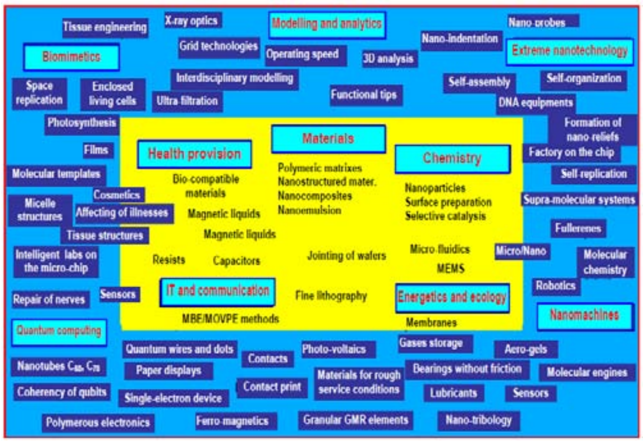

Figure 10: Applications of Nanotechnology and NPs in Scientific World.

Microscopy (TEM) and Atomic Force Microscopy (AFM) [41]. The typical particle diameter, their size distribution and charge influence physical strength and *in vivo* distribution of NPs. SEM techniques are very valuable in determining the general shape of polymeric NPs, which further determines their toxicity. The surface charge of the NPs influences their physical stability and redistribution of polymer dispersion, also them in their vivo performance.

Particle size

Particle size distribution and morphology are supreme vital factors of characterization of NPs. Particle size and Morphology are determined by SEM. The major application of NPs is in drug secretion and medication directing. It has been originated that particle size disturbs the drug secretion [42]. Reduced sized NPs proposes the greater surface area. Later, most of medications loaded onto them, will be open to the particle surface prominent too fast medication secretion. Comparatively, medications gently diffuse inside larger NPs. As a defect, smaller NPs tend to be comprehensive during storing and conveyance of NPs dispersion. Hence, there is a negotiation between a smaller size and maximum stability of NPs. Polymer degradation can also be disturbed by size of NPs. For illustration, the degradation rate of poly-lactic-co-glycolic acid had been established to rise with growing size *in vitro* [43]. There are numerous implements for determination of size of NPs, detailed below.

Dynamic Light Scattering (DLS)

Now, fastest and best prevalent technique for size determination, is Photon-Correlation 8Spectroscopy (PCS) or Dynamic Light Scattering (DLS). DLS is extensively used to determine the size of Brownian NPs in colloidal suspensions in nano and sub-micron ranges. Laser light at a solution of spherical NPs in Brownian motion originates a Doppler shift when laser light smashes moving NPs, varying the wavelength of smashing laser light. This variation is correlated to size of NPs. It is promising to abstract the size dispersal and provide a sketch of the NPs's motion in media, determining the diffusion co-efficient of NPs and using the auto-correlation function. PCS characterizes most repeatedly used method for precise approximation of size of NPs and size distribution established on DLS [44].

Scanning Electron Microscopy (SEM)

SEM is providing a morphological investigation with direct imagining. The methods based on SEM provide numerous compensations in morphological and size estimation; however, they offer narrow evidence about size distribution and exact population average. For SEM characterization [45], NPs solution should be initially converted into a dry powder, then mounted on a sample holder by coating it with a conductive metal (generally gold), using a sputter coater. Then sample is scanned with a concentrated fine beam of electrons. The surface characteristics of sample are achieved from secondary electrons discharged from surface of the sample. The NPs must be capable to endure the vacuum, while electron beam can also degrade the NPs polymer. The average size of NPs achieved by SEM is analogous with outcomes achieved by DLS. Furthermore, these practices are time-consuming, expensive and often require the corresponding evidence about size distribution.

Transmission Electron Microscopy (TEM)

TEM works on different principle than SEM, nonetheless, it often gets same information as SEM does. Sample making for TEM is difficult, complex and time serving as requirement to be ultra-thin for TEM. The NPs dispersion is coated on supported films [46]. To synthesize NPs, endure the instrument vacuum and simplify the supervision, they are stable using either a negative staining material (For example, phosphotungstic acid or derivatives, uranyl acetate, etc.) or by plastic inserting. Alternative technique is to expose sample to liquid nitrogen temperatures after inserting in vitreous ice. The surface characteristics of sample are achieved when a ray of electrons is transmitted through an ultra-thin sample, interrelating with sample of NPs as it passes through the sample of NPs.

Atomic Force Microscopy (AFM)

AFM provides the ultra-high resolution in size determination and is based on a physical scanning of samples of NPs at sub-micron level by a probe tip of atomic scale. Apparatus offers a geographical plot of sample based on forces between the tip and the sample surface. NPs Samples are usually scanned in contact or non-contact mode dependent on their properties. In interaction mode, the topographical map is generated by tapping the probe on to the surface across the sample and probe hovers over the conducting surface in non-contact mode. The prime advantage of AFM is its ability to image non-conducting samples without any specific treatment, thus allowing imaging of slight biological and polymeric nano structures and micro level structures. AFM delivers the most precise explanation of size and size distribution and needs no scientific dealing [47]. Furthermore, NPs size achieved by AFM method offers actual image which supports to realize the consequences of several biological environments.

Surface charge

The nature and intensity of the surface charge of NPs is very significant as it decides their collaboration with biological atmosphere and also their electrostatic contact with bio-active mixtures. The colloidal strength is investigated by zeta potential of NPs. This potential is a secondary extent of their surface charge. It resembles to potential difference among outer Helmholtz plane and shear surface. The extent of the zeta potential permits for expectations about storage stability of colloidal dispersion. High zeta potential values, either positive or negative, should be realized in order to ensure the strength and avoid the accumulation of NPs. The extent of surface hydrophobicity can then be projected from standards of zeta potential. The zeta potential can also offer evidence concerning with the nature of material summarized within the Nano capsules or covered at surface [48].

Surface hydrophobicity

Surface hydrophobicity can be predicted by numerous methods such as hydrophobic contact chromatography, biphasic separating, probes adsorption, contact angle determinations etc. Literally, numerous cultured investigative practices are stated in literature for analysis of surface of NPs. X-ray photon correlation spectroscopy allows the recognition of particular chemical groups on surface of NPs [49].

Drug release

An essential object for following the nanotechnology is to supply the drugs, therefore accepting the method and amount to which the drug molecules are secreted is significant. To get such evidence, most secretion techniques need that drug and its distribution vehicle be separated. The drug loading of NPs is mostly defined as extent of drug bound per mass of polymer (usually moles of drug per milligram polymer or milligram drug per milligram polymer); it could also be assumed as percentage comparative to NPs polymer. The method used for this investigation is classical analytical methods (like UV spectroscopy or High Performance Liquid Chromatography (HPLC) after ultracentrifugation, ultrafiltration, gel filtration, or centrifugal ultrafiltration). Quantification is done with the UV spectroscopy or HPLC. Drug discharge analyzes are also analogous to drug loading assay which is evaluated for a time period to investigate the mechanism of drug [50].

Applications of NPs

Nanotechnology along with information technologies and biotechnologies belong to each other, and so-called "emerging" technologies. An imperative development in understanding the phenomena and methods in the nano-world, which nanoscience has prepared in recent twenty years, facilitates to expect that their applications and understanding will convey break-through changes mainly in electronics, photonics and computers, but also in other areas (Figure 10), such as health and dispensary, power industry and environment safety, farming, armed forces and other productions, e.g. textile [51].

Currently, NPs in many circumstances have left laboratories already and have become objects of real-world usage. The primary application of NPs arisen in methods, in which powders with nanometer levels could be utilized in a bulk quantity, without compaction and collaborating. Titanium oxide and Zirconium oxide NPs are usually applied in cosmetics in face beauty creams, in sunburn face lotions [52]. Ferric Oxide NPs are applied as a base stuff for blushes and make-ups. Recently, they were used experimentally for cleansing and reclamation of a dirty region in North Carolina (USA). Nowadays, dyes with reflective properties are made by adding Titanium oxide NPs.

Nanostructured abrasion-resistant varnishes for cutting tools and their constituents have been utilized for numerous years previously. Tiles with a NPs surface film, to which either water or dirt does not switch, have been set on the market. In the locomotive industry, nanocomposites polymer–clay have been applied. Adding the only 5% of NPs of montmorillonite in the polymer matrix, may results in an important rise in composite strength. Cerium Oxide NPs addition to the engine fuel in order to decrease its consumption has been tested, too [53].

Recently, much cultured use of NPs has been appreciated in information technology. In construction of silicon transistors, precise deposition of coated structures only numerous atoms thin has been applied and adjacent dimensions of the transistor gate critical length have usually reached 180 nm; in 2003 some manufacturer have declared attaining the value of 90 nm [54]. A smaller measurement of gate allows the manufacturing of slighter, earlier and more energy proficient transistors and conforming cheap price and enhanced yield of every numerical scheme. Alike, the read heads of standard hard discs, thanks to the coated hetero-structures of NPs, take improvement of enormous magnetic resistance, considerably growing their memory volume, while dropping a rate. Micro-electronics leads to nano-electronics.

In medical, liposomes were manufactured, permitting enhanced directed delivery of healing agents. Liposomes are lipid domains of a diameter 100 nm. They are used for encapsulation of anti-cancer medicines for cure of Kaposi's sarcoma interrelated to AIDS [55]. Several corporations utilize the magnetic NPs for analysis of blood, urine and other body solutions to speed up the separation and develop the differentiation. Other corporations have established fluorescent NPs, which are the origin for novel discovery tools.

These active NPs are used in devices and systems for analyses of infectious and genetic diseases and research of medicaments. One Chinese company has put an antibacterial nano-powder on the market. NPs have found a wide usage in the defense industry and in scientific and technical instruments. Manufacturers of optical materials and electronic substrates, such as silicon and Gallium Arsenide (GaAs), use NPs for chemical-mechanical polishing. Silicon carbide, diamond and boron carbide NPs are used for lapping of components in order to minimize surface waviness to 1/2 nm [56]. An opportunity to produce high quality components is important for scientific applications and will be still more important for gradual miniaturization of electronic devices and development of optoelectronic systems. Nanotechnology has broken even to clothing and sports. For instance, crease resistant and soil and stain resistant cotton fabric with nanoparticle addition is produced, tennis rackets with frames reinforced with carbon nanotubes and tennis balls with the inner layer of polymer-clay nanocomposites extending their service life [57].

Specially prepared semiconductor crystals-quantum dots are tested, which are intended i.e. for analyses of biological systems. Upon putting on a light, these dots emit different colors of light depending on their dimensions. Quantum dots of different dimensions can be connected to various molecules in biological reactions, allowing monitoring of all molecules participating in biological processes at the same time. Quantum dots may also be used as a tool for faster DNA and antidotes testing than at the present time. Progress in nano-powders filling into commercial sprays is promising, too. In the near future this will enable to coat plastic materials with nano-powders, improving their abrasion resistance and corrosion resistance [58]. Automotive industry investigates possibilities for applications of polymer nanocomposite materials in parts requiring meeting conditions of low weight and high impact strength at the same time. Some companies have already presented parts manufactured by injection moulding. Prototypes of these parts are subjected to demanding tests and full use of these materials is expected in the immediate years. In the aerospace technology, research programmes for the use of aluminum and hafnium NPs for rackets fuel are performed [59]. For this purpose of use, the important factors are improved burning and ignition velocity of particles.

Applications of nanomaterials in surface finishing in abrasion-resistant and corrosion-resistant coatings formed on various substrates and in coatings on surfaces participating in catalysis have been developed. The leading candidates for the manufacture of filters for fluid separation in industrial processes or cleaning of waste liquids are TiO2 and ZrO2 NPs, exhibiting ability to capture heavy metals and bio-organisms. New ceramic nanomaterials will be applied in the manufacture of water jets, injectors, lasers, telescope mirrors of low weight, jacketing of arm systems and for anode and cathode surface coating in power industry facilities [60].

Advancements in the research of photonic crystals, which are elements based on phenomena exhibiting in nano-dimensions, offer their applications in optical communication networks resulting in a significant increase in their efficiency. Small and cheap optical switches are a key to the development of a full potential of rapid and wideband optical communication networks.

Conclusion

After a long discussion it is cleared that Nanotechnology has brought numerous scientific development in the area of research and expertise. NPs is a core particle which performs as a whole unit in terms of transport and property. Nano size particles are quite unique in nature because nano size increase surface to volume ratio and also its physical, chemical and biological properties are different from bulk material. So, the main aim to study its minute size, is to trigger chemical activity with distinct crystallography that increases the surface area [61-64]. Nanotechnology represents the design, production and application of materials at atomic, molecular and macromolecular scales, in order to produce new nano-sized materials. The synthesis of NPs mainly done by several different chemical, physical and biological methods [65]. Each method has its own significance and Nanoparticles synthesized by a specific method are utilized in a specific field. On characterization, it is concluded that NPs are the best advanced materials to apply in almost every field of research and technology for routine life applications [66]. NPs are applied now a day in medical fields for diagnosis of diseases, and their cure. These are applied in electronic industries to make nano-chips and microchips. Along with, there are used in health and dispensary, power industry and environment safety, farming, armed forces and other productions [67]. Hence, in every filed of research and technology and also in our routine life uses, NPs are extensively used.

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Austin J Nanomed Nanotechnol - Volume 7 Issue 1 - 2019
ISSN : 2381-8956 | www.austinpublishinggroup.com

Citation: Fazal-ur-Rehman M, Qayyum I and Rehman R. Nanotechnology; A Great Innovation in Scientific Research and Technology-A Review. Austin J Nanomed Nanotechnol. 2019; 7(1): 1051.