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Nanoparticles-A Picture Who Worth`s a Thousand Words in Biotechnology

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Abstract

The field of nanotechnology holds the central position in biomedical field and used for the construction of materials ranges in "*nanometer*". These nano-sized objects differ remarkably from other identical traditional objects due to their novel physio-chemical properties. Synthesis of nanoparticles (NPs) with controlled protocols has been one of the major goals in biotechnology. NPs have revolutionized the biomedical field and acts as a splendid carrier in Drug-Delivery System (DDS). Controlled drug delivery system has many advantages over traditional forms, as it maintains a specific and controlled rate of drugs to perform an action on the site of infection. Cell-specific targeting is all due to especially composed carriers, which works specifically on target positions. Discoveries in the past decade have clearly shown that the electromagnetic, optical and catalytical properties of these NPs are greatly influenced by size, shape and distribution, which are varied by varying the reducing agents, stabilizers and the synthesis methods. An extensive review of literature has been conducted to emphasize all the synthesis aspects of NPs, computational behavior of binding of nano-carriers to biomolecules and their applications in various fields. Finally, current limitations, trials and future perspectives of NPs are also critically discussed.

Keywords: Nanoparticles; Nano-carriers; Targeted delivery; Biogenic; DDS; Biomolecules

Introduction

The word "*Nano*" is derived from Greek language, which includes particles in the size range of 1 to 100 nm. In the past decade, there has been a remarkable increase in the field of fabrication of nano-particles with controlled morphologies and unique features making it an extensive area of research [1]. Nano-particles have novel physio-chemical characteristics as compared to other solid bulk objects i.e. they have large reactive area and exceptional electronic properties. The small size, even surface, good solubility, and poly-functionality of nano-particles will persist to open many caves and do wonders in biomedical fields [2]. Different synthetic approaches have been used for the preparation of nanoparticles with novel morphologies. However, the main focus is to design NPs using environmentally benign approaches. These provide solutions to future challenges related to environmental issues [3]. After synthesis, characterization is done by various biochemical techniques to adjust their size, shape, and reliability.

These nanoparticles are the center of attraction as drug delivery system due to their ability to diminish toxicity of the therapeutic agents in neighbour cells and also have selectively augmented the number of drugs accumulated within target cells [4]. Characterized nanoparticles are then coated with drugs and introduced into the body, where they can reach to the specific site and perform their functions. The importance of targeted drug delivery is to carry drug directly into the site of infection and then treat it freely, with no harm to the body [5].

This review article has discussed in detail with wide range of imminent of synthesis methods for nanoparticles and overview the most recent developments and applications in nanotechnology with main focus on role of different nanoparticles as DDS. Moreover, it also focuses on the binding of the synthesized NPs to various drugs and biomolecules, which can then be used in various fields. One of the major advantages of these synthesized NPs is their ability to uniformly, modify the properties of nanostructures by controlling their structure and their surface properties which makes them extremely efficient candidates for use in biological fields, from basic scientific studies to commercially viable technologies.

Synthesis of nanoparticles

Many techniques have been utilized to prepare nanoparticles. Techniques utilized for the preparation of NPs are physical, chemical and biological [6], which further includes various processes as shown in Table 1.

Green Methods	Chemical Methods	Physical Methods
Using Bacteria	Chemical reduction	Pulsed laser ablation
Using Fungi	Sonochemical	Evaporation
Using Plants	Microemulsion	Arc discharge
Using Yeast	Pyrolysis	Ball milling
Using Enzymes	Coprecipitation	Lithography

Table 1: Approaches to synthesis of nanoparticles.

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Physical approach

Physical methods are mostly used to achieve nanoparticles that have steady shape and size but can be altered by the heat, power, and discharge to make them favorably use in desired place. In physical processes, metal nanoparticles are commonly prepared by evaporation–condensation, which could be carried out using a tube furnace at atmospheric pressure. The other preparation methods are lithography, ball milling, arc discharge and the pulsed laser ablation. All these methods require serious handling and safety must be considered in mind while working with NPs.

In Physical approach, metal NPs are for the most part synthesized by evaporation–condensation. This procedure is completed in a tube heater at air pressure. The source material inside a boat sets at the center point of the furnace which is then vaporized into a carrier gas. Gama-irradiation procedure is common technique for the preparation of NPs with uniform size and high immaculateness, utilizing polysaccharide alginate as a stabilizer. Microwave Irradiation method was utilized to synthesize nanoparticles by reducing agents, for example, citrus acid and a coupling agent, like, Cetyl Tri-methyl Ammonium Bromide (CTAB). Moreover, NPs are also synthesized by utilizing HAuCl4 by tartrate, citrate and malate in a photochemical reduction process. A typical procedure of photochemical reduction includes polymerization chain reaction which yields gold polyethylene glycol nanoparticles with size ranges in 1-50 nm [6].

Researchers have concluded many physical techniques for the synthesis of nanoparticles. For instance, the preparation of nanoparticles in solid state needs thermal decomposition technique. Preparation of the uniform and mono-disperse NPs is additionally accomplished by utilizing ceramic warming procedure. Tien and his colleague revealed a technique to prepare NPs by utilizing discharge method. Spattering of metal into reaction mixture nanoparticles is prepared [7]. The milling processing likewise makes some adjustment in micron-sized particles. Many kinds of processing machines are used in this procedure which involves the utilization of hardware needed in the preparation of nanoparticles. This process has a few disadvantages, incorporating troubles in the production of large particles that require a long period of time to complete [8].

One of the latest techniques is the Pulsed Laser Ablation based preparation of colloidal metal NPs for reactant-based properties as shown in Figure 1. Nanoparticles synthesized by Pulsed Laser Deposition (PLD) in a gas stage are for the most part kept on strong solid substrate. Colloidal NPs very much scattered in fluid mostly are not promptly accessible. So, Pulsed Laser Ablation in Liquid stage (PLAL) is the best method for those nanoparticles, which cannot be approach-able easily in a fluid arrangement. This procedure uses laser beam to concentrate a huge target, which are submerged in a fluid. The characteristics of these NPs formed and the efficiency strongly depends upon many things such as the wavelength of the laser, the time period of the laser pulse and the effective liquid media. The main part of the objective can be an element or a compound. One major advantage of this technique is the absence of chemical reagents, so pure colloids which will be useful for further applications can be produced. Moreover, metal nanoparticles with moderately "*exposed and clean*" surfaces arranged by physical laser ablation are significantly favored for catalysis [9].

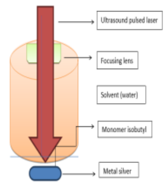

Figure 1: Set up of pulsed laser ablation in liquid media.

The common demerits of physical techniques are that they require costly vacuum systems for the preparation of nano particles. And also, these procedures are time consuming and require high energy [9].

Chemical approach

Chemical Approach was recommended by Gimenez to synthesize nanoparticles by the reduction procedure of the HAuCl4 through the solution of thiolated chitosan [10]. Reduction of chemicals is the most general approach for the synthesis of NPs as steady, colloidal scatterings of natural solvents. Generally utilized reducing chemicals are the natural hydrogen, citrate, borohydrate and ascorbate. The reduction of these metals in aqueous solution commonly yields colloidal metals with particle diameters of several nm. Use of weaker reductant i.e. citrate results in slow reduction rate but the size distribution is far from narrow [10].

Chemical Vapor Deposition (CVD) is a well-known procedure in which the solid substrate is deposited on a warmed surface by means of a chemical reaction in a vapor or gas state. CVD reaction needs initiation energy to continue the process. This activation energy can be given by different strategies. In Thermal CVD the activation energy comes by heating the surface over 900°C. A typical apparatus consists of gas supply system, deposition chamber and an exhaust system. In plasma CVD, the reaction is initiated by plasma at temperatures between 300°C-700°C. Nano composite powders have been prepared by CVD as shown in Figure 2. These films are then modified and make uniform and strong. Noteworthy advance has been made in nano-structured coatings shaped by CVD. Numerous other non-ordinary procedures, for example, Hypersonic Plasma Particles Deposition (HPPD) have been utilized to prepare and store nano-particles [11].

Figure 2: Flow chart of various steps in CVD.

One of the most recent methods is the production of Europium ortho-chromites (EuCrO3) nanoparticles by combustion reaction process. The solid state reaction has been common technique used to prepare uncommon earth ortho-chromites. Similarly, for getting single stage materials by using this technique, it requires long time period (up to 70 hrs) and temperature near 1473 K. Thermo chemical ideas utilized in propellant chemistry set up the standards for the combustion reaction preparations. The reaction is specified by exceptionally exothermic. Once the combustion reaction starts, it is automatic yielding the final product in a short frame of time. Along with these sample preparing procedures, the combustion reaction is remaining parts less utilized regardless of their straight forwardness, minimal effort, and environment inviting nature, simplicity, simple stoichiometric control and saving the energy [12].

Biological approach

The conventional methods for the production of NPs are expensive, toxic, and non-environment friendly. To overcome these problems, researchers have found the precise green routes, i.e., the naturally occurring sources and their products that can be used for the synthesis of NPs [13]. Green synthesis is divided as:

- Utilization of microorganisms like fungi, yeasts (eukaryotes), bacteria, and actinomycetes (prokaryotes).
- Use of plants and plant extracts.

Nanoparticle synthesis using microbes

The microbes have been appeared to be essential nano-factories plants that hold monstrous potential as financially cheap devices and eco-friendly, instead of poisonous, dangerous chemicals and the highly exothermic reaction needed for chemical and physical preparation. Microbes can collect and detoxify heavy metals into various reducing compounds that can reduce metal salts to metal nanoparticles with a thin size. Any array of biological protocol for NPs synthesis have been seen using bacterial biomass and derived components. Similarly metal-resistant peptides, enzymes and genes act as a reducing agent and also help in natural capping to protect nanoparticles from aggregation and remain stable from a long period [7].

Microorganisms including *Pseudomonas deceptionensis*, *Weissella oryzae*, have been used for silver and gold nanoparticles preparation as shown in Table 2 [14,15]. For the similar production of nanoparticles by utilizing several *Bacillus* and other species of bacteria including *Bacillus licheniformis* has been showed great potential [16]. These processes recommend that production of nanoparticles require enzymes, for example nitrate reductase used in preparation of silver nanoparticle in *B. licheniformis*.

Microorganism	Types of NPs	Extracellular/ Intracellular	Size (nm)	Shapes	Application
Bacteria					
Pseudomonas/ Deceptionensi	Silver	Extra-cellular	10-30 nm	Spherical	Anti-fungal Anti-bolism
Weissellaoryzae	Silver	Intra-cellular	10-30 nm	Spherical	Anti-viral Anti-bolism
Bacillus methytotrophicus	Silver	Extra-cellular	10-30 nm	Spherical	Anti-bacterial
Brevi-bacterium, Frigoriclerans	Silver	Extra-cellular	10-30 nm	Spherical	Anti-viral
Fungus					
Neurospora crassa	Silver and bi-metallic	Intra, Extra both	>100 nm	Spherical	_

Table 2: Applications and synthesis of nanoparticles from microorganisms [7].

Instead of utilizing bacteria, myco-synthesis is a clear approach for accomplishing steady and simple biological NPs preparation. Many fungi which contain vital metabolites with huge bioaccumulation capacity are used but it is difficult to culture them for the proficient, minimal effort, generation of nanoparticles [17]. Also some fungi have higher resilience for metals, especially the high divider restricting capacity of metal salts with parasitic biomass for the large return creation of NPs. The mechanism of synthesis is similar to bacteria [18]. Most microorganism based synthesis of nanoparticles is moderate with low production, and for returning to good productivity of NPs it needs downstream preparation. Moreover, issues identified with microorganism based production for NPs which also includes complex processing, for example microbial examining, maintenance, refined, isolation and culturing [19].

Nanoparticle synthesis using plants

Currently, phyto-nanotechnology has introduced cheapest and effective approaches for the synthesis of nano carriers and they are environmental friendly and simple. Phyto-nanotechnology has many beneficial effects, including scalability, biocompatibility and the medical applicability of synthesizing nanoparticles using the universal solvent as a reducing medium. Hence, plants-made nano carriers are generally generated by commonly available plant materials and the non-toxic properties of plants are helpful for completing the large requirement for nano-carriers with utilization in the medical and environmental sites. Various plants have been used for the preparation of NPs as shown in Table 3 [20].

Plants	Extraction from plant tissues	Forms of nanoparticles	Applications
Ginkgo Biloba	Plant leaves	Cu	Catalytic
Red ginseng	Root	Ag	Antibacterial
N. sativa	Plant leaves	Ag	Cytotoxicity
C. nucifera	Plant leaves	Pb	Anti-microbial
Panax ginseng	Root	Ag	Antibacterial
Azadirachta indica	Plant leaves	Ag	Biolarvicidal

Table 3: Applications and synthesis of bio NP's from plants.

Recently, successfully synthesized gold and silver nanoparticles using the leaf and root extract from the medicinal herbal plant *Panax ginseng* suggested the use of medicinal plants as sources. Additionally, various plant parts, including leaves, fruits, stems, roots, and their extracts, have been used for the preparation of metal nanoparticles It has been proposed that proteins, amino acids, organic acid, vitamins, as well as secondary metabolites, such as terpenoids, heterocyclic compounds, polyphenols, flavonoids, alkaloids and polysaccharides have useful roles in metal salt reduction and, furthermore, act as capping and stabilizing agents for synthesized nanoparticles [21].

It has been seen that green synthesis using plant and plant extracts appears to be faster than other microbes, such as bacteria and fungi. The use of plant and plant extracts in green synthesis has drawn attention because of its fast growth, providing single step technique, economical protocol, non-pathogenic, and eco-friendly for NPs synthesis.

Characterization of nanoparticles

Characteristics of nanoparticles are significant to understand and to convert them in fully active form. Characterization is carried out having a mixture of various approaches like atomic force microscopy (AFM), X-rat photo electron microscope, (XPS), transmission and scanning electron microscope (TEM, SEM), powerful light scattering (PLS), UV–Visible spectroscopy, Fluorescent transform infrared spectroscopy and X-ray diffractometry [21]. These approaches are helpful for the measurement of various limitations like shape, size, crystallinity, vesicle size and area of the surface. Further, orientation, interrelation and diffusion of nano-carriers and small tubes in Nano-composite concrete can be resolved by these approaches [7].

Comparatively, TEM, SEM and AFM could judge the physical appearance and particle volume. The dominance of AFM over recent microscopes such as SEM and TEM is that AFM quantify images by three dimensions so that material length and size can be obtained. Moreover, dynamic light scattering is characterized for obtaining material volume distribution. Furthermore, X-ray diffraction is characterized to check crystallinity while UV–Visible spectroscopy is characterized to sure sample constitution by giving the Plasmon resonance [22].

Nano-carriers as drug delivery system

Present progresses in nano-techniques have seen that nano-carriers have a high ability as drug particles. Due to the small volume of Nano-carrier, the small structures express novel physical chemical and biological characters (e.g., an increased surface area along with good capability to across cell wall and tissues) which make them a beneficial material for medical uses. Nano-carriers with optimal physical and chemical and biological characters are taken up by cells more comfortably than larger molecules, as they can be strongly applied as delivery equipment for recently used biologically active materials [23].

Cell-specific object can be achieved by combining drugs to especially composed particles. Many small structures, involving liposomes, dendrimers, silicon and carbon materials, and magnetic nano carriers, has been used as particles in Drug Delivery Systems (DDS). The method of combining the drug to the nano-carrier and the method of its targeting is more beneficial for a target objective therapy. A stimulant may be consumed or covalently combined to the nano-carriers outer surface or else it can be enclosed into it. Following are the nano-carriers, which are used in DDS [24].

Liposomes

The word liposomes were procured from a Greek word "*lipo*" which means fat and soma meaning mass. They have a vesicle-like structure that is biologically active compounds having a diameter of 15-1000 nm. They have bilayer structures used for drug delivery system. Drugs are filled in liposomes to cancer treatment and other diseases [25].

Recently, liposomes used in gemcitabine delivery system for cancer therapy to improve the safety and efficacy of cytotoxic drugs. It also provides insight into the design and development of gemcitabine conjugation for safe and effective cancer therapy. This combined approach of drug delivery systems and gemcitabine conjugates has shown significant potential and efficacy in preclinical models for future cancer-therapeutic applications [26]. There are also some disadvantages of liposomes drug delivery system i.e. not cost effective and production is also high [27].

Dendrimers

Dendrimers are the class of polymeric material that ranges from 1-100 nm in diameter. Dendrimers are made up of carbon, nitrogen, oxygen and many other elements and they are spherical branched structure. Dendrimers provide a platform for specific ligand attachment and these compounds or ligand improve the biological and physical properties by attaching to the specific receptors on the body [28].

Dendrimers were used as multi-functional polymers that have been popularly studied for their potential to be utilized for the diagnosis, prevention, and treatment of CVDs. Specifically, dendrimers having primary amine end groups that can interact with compact DNA plasmids or siRNA by electrostatic interactions. Then forming nano-composites which favor the cell uptake process and releasing DNA into the cells to complete the following transcription and translation [29]. There are also some limitations of dendrimer i.e. if positive dendrimers are used then it may interact with blood components and cause cell lysis. And their effect is also toxic [28].

Polymeric

Polymeric nanoparticles are structures ranges from 10-100 nm in diameter obtained from synthetic polymer like polyacrylamide or natural polymers like DNA, Albumin, and gelatin. There are many properties of polymeric nanoparticles that are used in drug delivery i.e. they are non-toxic and remain stable in the body [30].

Polymeric nanoparticles especially Poly (b-amino ester) plays an important role in decreases the barriers of solid tumor. They create a microenvironment, in which responsive material for tumor growth are reversed. In solid tumor the immune treatment efficiency is limited due to barley infiltration of immune cells. Recently, researchers work on conversion of supportive tumor macrophages to tumor against ones and it has been good out-coming method that contributes the antitumor response and induced the functional reverse effect of macrophages [31].

There are also some limitations of polymeric nanoparticles i.e. their surface area is large and particle size is small, which makes particle-particle aggregate. That causes dry and liquid form of nanoparticles difficult to handle [30].

Solid lipid

Solid lipid nanoparticles are unique particles ranges from 1-1000 nm. These Nano-carriers are made up of solid lipid purified triglycerides. Their main properties are good physical stability, protect the drug from degradation and also have better control of drug realization [32].

Innovative approaches of SLNs are successfully used to improve absorption and solubility of GI tract of lipoyl-memantin, which are very effective against Alzheimer diseases. Chemical and physical characteristics of LA-MEM have been seen through differential scanning calorimetry, which shows the crystalline structure. In novel delivery system, drug are loaded with LA-MEM 566 which was characterized and manufactured in term of chemical and physical properties, entrapment efficacy and released profile in 568 GI fluid. Several in vitro biological tests shows that solid-lipid LA-MEM are suitable as DDS in brain and it is also save from toxological point of view [33]. They also have one major disadvantage such as having short gastric retention [32].

Magnetic

Magnetic nanoparticles show a wide range of attributes, which make them efficient carriers for drug delivery. They range in size up to 5-100 nm. Magnetic nano-carrier has a magnetic base and a superb magnetic outer-covering, which improves magnetic effects of these nano-carriers. Improved magnetic effects of the magnetic nano-carrier acknowledge for easily detection and decrease non-specific accumulation of nano-carrier Magnetic nanoparticles can be introduced over vascular organization for magnetic purpose. The biochemical applications of MNPs such as magnetic labelling, hyperthermia cancer treatment, target drug delivery and magnetic resonance imagining all depend upon having magnetic core [34].

Due to the magnetic behavior of MNP's, they have so many advantages in the field of diagnosis such as for cancer. They can also be separated from food matrix using magnet and this process also avoids the filtration steps involved in any mechanism and they also are not needed for column packaging for which the process is so quick. [35]. Magnetic nanoparticles have some limitations i.e. magnetic field is not capable abundantly to reduce the strength of blood out flow and acquire magnetic therapeutics at a specific area [36].

Silica

Porous silica nanoparticles have a pore size about 2-50 nm. The shape of porous silica nanoparticles helps in fusion of both large and small particles, as attachment of DNA on surface, and gene transformation. Porous silica nanoparticles were first introduced in the ancient of 1990s. In general, silica nanoparticles are introduced *via* a template-directed method [37]. For treatment, diagnosis and biological imaging many silicon bases systems are being used which includes silica NP and dye NP. For biological imaging nano probes are used with silicon quantum dots. In drug delivery system for tumor therapy HMSNs are also used. HMSNs are the reservoirs of drug against cancer [38].

There are many disadvantages of silica nano-carriers i.e. if it present at high amount cause bad effects on cells of bronchial epithelial. Some inflammations held in body causes initiation of several cytokines and chemokine's like TNF and interleukins [39].

Other application of nano-particles

Due to more developments nanoparticles are applicable in many others fields such as oil, biomedical, agriculture and food production, agro waste and use of magnetic nanoparticles in cancer therapy and diagnosis. Some of them are discussed below.

Biomedical applications

Nanoparticles involve novel strategies which are used for the diagnosis of diseases, gene therapy of cancer, drug delivery and prevention of other infections also. Cancer is the abnormal division of cells which enter into normal adjacent body tissues and destroy them completely [40].

Nanoparticles (NPs) are used to overcome limitations in chemotherapy and other conventional treatments. Nanoparticles in drug delivery are made of different sizes (1-1000 nm) and different materials depending upon the use e.g. magnets for hyperthermia (magnetic nanoparticles), liposomes (solid-lipid nanoparticles). They can also carry imaging probes with the drugs designed to target specific molecules in diseased tissues. In cancer therapy and diagnosis numerous advantages of nanoparticles have been observed which include prolonging circulation time, minimized non-specific uptake, enhanced solubility of hydrophobic drugs, preventing off-target and harmful effects, improved intracellular specific targeting in cancer therapy. Nanoparticles are delivered by passive and active targeting to enhance intracellular concentration of drugs and avoiding effect on normal cells. They can also be further modified to lower toxicity [41].

Magnetic nanoparticles in cancer therapy

Due to stability, magnetic susceptibility and other physical properties of magnetic nanoparticles MNP's, they have a major role in cancer therapy at the exact cancerous site as shown in Figure 3. These nanoparticles are controlled by the external magnetic field that allows the effect of anti-cancer agent at the exact site and at exact time.

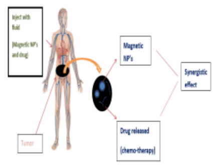

Figure 3: Therapeutic agents based on Magnetic Nanoparticles for treatment of cancer using thermo-chemotherapy.

Magnetic nanoparticles are used in many other processes like MRI imaging of magnetic resonance, hyperthermia, delivery of drug etc. In the therapy of cancer hyperthermia is important because of its effect against cancer. In hyperthermia, the effected cancerous tissues are exposed to the unusually high temperature (41°C–49°C). As it was revealed in nineteenth century describing that cancer cells are very sensitive to the high temperature (Hyperthermia) by which apoptosis occur. Magnetically induced heat has shown effects against cancerous tissues and allowing nanoparticles to produce anti-cancer agents on the target site [42].

To overcome the traditional remedies, magnetic nanoparticles are used for the effect on exact target site. In this therapy, injection of the colloidal suspension of magnetic nanoparticles is used, that gathers at cancerous site both actively and non-actively. In active state ligands are used with MNP's and the inactive state in which retention and permeability of MNP's are increased. MNP's having external magnetic source can gather at tumor site and covert this magnetic energy into heat. The technique of using MNP's does not harms the surrounding tissues of target site due to heat. This cancer treatment is non-invasive and non-toxic which makes it different from the old styles [36,43].

Nanotechnology in agricultural and food production

Different types of nano-materials, mostly carbon-based nanomaterial and metal-based nanomaterial, have been utilized for their absorption, accumulation, translocation and beneficial effects on growth and development of crop plants. The beneficial effects includes enhanced germination percentage and rate, vegetative biomass of seedlings and increased length of root and shoot in many crop plants including radish, lettuce, spinach, onion, pumpkin, soybean, rape, tomato. Nano-foods are the foods in which nano-technological approaches are used during production, processing or packaging of the food. Foods made by nanotechnology are rapidly coming into the market which includes cooking oil called Canola Active Oil. The canola oil contains a space cavity called nano drops, which are made to carry minerals, vitamins and phytochemicals through the digestive system and urea. Some nanomaterial which are made of two or more layers known as nano-alminates are suitable and being used in food industry and are also used in edible coatings of food like vegetables, chocolate, fries, meats, and bakery products and these coatings can also act as barrier to gases, lipids which is one of a great advantage of nanotechnology [44].

Applications of nanotechnology in agro-waste reduction and biofuels

For filtering water of low quality, pollutants which can harm water and removal of salt is done by nanotechnology. Different nano-materials can also stimulate metabolism of microorganisms without harming them, examples of that nano-materials are calcium oxide, magnesium oxide which can be used as carrier in the processing of transesterification of oil into biodiesel [45].Some nano-materials are cellulose based which are used in biomedical processes as potential filler [40].

Oil industry based on nanotechnology

The unique chemical and physical properties of nanomaterial have implications on almost all oil and gas processes, such as exploration, reservoir consumption, drilling, cementing procedures, production and Enhanced Oil Recovery known as (EOR). To create lighter, resistant to corrosion and stronger effects nanotubes are used in gas industry. Nanotechnology can also help in improving gas and oil production by making it easier to separate them, by making improvements at the molecular level. Recently, petroleum laboratories has made an advanced fluid mixed with nano-sized particles and superfine powder that enhances the drilling speed and also prevents damage [46].

Textile industry based on nanotechnology

Due to the increased sustainability and less cost production provided by NPs in textile industry, fabrics are made by them. For large surface area fabrics nanoparticles can provide durability and sufficient energy which increase its function. By using nanotechnology various functions of fabrics can be enhanced like antimicrobial, UV protection, easy clean and anti-odour. Ag NP's are used to kill microbes and prevent bad odours in socks and sports clothing [47].

Cosmeceuticals based on nanotechnology

The product between a drug and a cosmetic is called cosmeceutical and it is a rapidly increasing segment of personal care industry. The unique property of liposomes i.e. biocompatibility, biodegradability, nontoxicity and flexibility in vesicles makes them suitable to become a main constituent of cosmeceutical [48]. Phosphatidylcholine is one of the vital components of liposome and it has been, utilized in products for skin (moisturizing creams, body lotions etc.), products for hair (shampoo for hair fall and color prevention, conditioner for shiny hair) because of its silky and conditioning nature. A number of nanotechnology-based products of cosmeceutical industry are there in the market used as anti-aging, cleanser, anti-wrinkle and moisturizer [49] (Table 4).

Types	Advantages	Disadvantages
Liposome	Help in drug loading with different solubility's.	Toxicity Rapid uptake through reticuloendothelial system [27].
PLGA	Biocompatibility of cargo has high capacity.	Greater ratio *in vivo* Whole body bio-distribution and bone targeting are needed [32].
Mesoporus silica	Loading capacity Biocompatibility Surface functionality.	Restricted use in practical application due to high cost of organic template lead and limited availability [39].
Metal-nanoparticles	Bone-bioactivity related to ionic release.	
Hydroxyapatite	Use in drug delivery, MRI, Hyperthermia treatment and thermolysis by radiofrequency. Bone tissue grows with the help of nano-carrier; also promote the bioactivity of osteoblast.	In intravenous case spontaneously aggregate and cause vessel embolism. Hardly processed material due to its brittleness [36].

Table 4: Advantages and Disadvantages of Nanoparticles.

Conclusion

Nanotechnology is the science of minute preparation dealing with production, approach and manipulation of particles. Due to the improved features based on their nature, new applications of nanoparticles and nanomaterials are developing rapidly in various areas i.e., farming and nourishment, nanofertilizers, petroleum, clothing and cosmeceutical [50]. They can be manufactured by a number of techniques i.e. Physical, chemical and Biological using plants and microorganisms as a source. NPs are characterized by multiple techniques to adjust their size and shape. By making specific changes in shape, size of medicine and its properties activated nanomedicine with increased action by a little drug at target site are achieved. Novel drug delivery system is crucial in target specific drug supply compared to custom dosage forms because of specificity and stability. Nano-particles became very famous transport system of medicine as it promotes the chances of survival and prevents drug molecules from urgent breakdown [51].

Future Prospects

The combination of nanotechnology with medicine has manufactured a product which in turn has enhanced the fight against a number of diseases. In reality, nanomedicine is a product of latest research that has led to cure devastating diseases. Targeted drug delivery is now emerging fast due to its potential to transport drugs at specific sites [52]. The main purpose in further evolution of nanomaterials is to render them versatile in function and governable by signals coming from external or by local environment and hence crucially turning them into nanodevices. They all outline the bright future of targeted drug delivery [53].

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