International Journal of PharmTech Research
CODEN (USA): IJPRIF ISSN : 0974-4304
Vol.6, No.5, pp 1712-1717, Sept-Oct 2014

Beneficial Applications of Nanoparticles in Medical Field – A Review

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Abstract : Nanoparticles may provide advanced biomedical research tools based on polymeric or inorganic formulations or a combination of both. They have the potential to be used in many different biological and medical applications as in diagnostic tests assays for early detection of diseases, to serve as tools for noninvasive imaging and drug development, and to be used as targeted drug delivery systems to minimize secondary systemic negative effects. Nanoparticles have contributed too many allusing advances in medical field. Because of its greater surface area per weight than large particles it has one dimension (i.e.) it measures 100nm or less. Despite size it has advantages over shape, biocompatibility and selectivity. It changes the properties of conventional materials. The main aim of this review is to bring out the beneficial application of nanoparticles in medical field
Keywords: Nanoparticles, biomedical, drug development, biocompatibility

1. Introduction

In nanotechnology, Nanoparticles are being used in medical field to create different therapies and treatment for different diseases. Nanoparticles are being used in many branches of medicine one attribute these particles have in common is that they need to be biocompatible. Medicine still has many unsolved problems and nanomedicine may hold the key to some of the problems. In general the size and materials of the nanoparticles are very important and specific. Specificity allows nanoparticle to be used to treat specific problems in the medical field the use of nanoparticles in the field of medicine could revolutionize the way we detect and treat damage to the human body and disease in the future and many techniques only imagined a few years ago are making remarkable progress towards becoming realities. On the whole Nanoparticles may or may not exhibit size related properties that differ significantly from those observed in fine particles or bulk material [1].

The small nature of Nanoparticles allows them to cross cellular membranes and avoid detection by the reticuloendothelial system and their high surface area to volume ratio can allow increased loading of therapeutics; such properties makes NPs desirable for diagnostic and therapeutic applications which are briefly detailed, as follows [2-5].Nanoparticles are employed for imaging in a variety of ways, both for medical purposes and further understanding of biochemical processes in vitro and in vivo [6]. General reviews covering the applications of a variety of materials for biomedical imaging including Au, QDs, and magnetic Nanoparticles have already been published elsewhere [7, 8].

Significant interest has arisen in the research of Nanoparticles during the last decade, in particular for biomedical applications. The integration of nanotechnology into the field of medical science has opened new possibilities. Working with nanomaterials has allowed a better understanding of molecular biology. As a consequence, there is the potential of providing novel methods for the treatment of diseases which were previously difficult to target due to size restrictions. For biomedical applications, the synthesis of biofunctional Nanoparticles is very important, and it has recently drawn the attention of numerous research groups, making this area constantly develop. Nanoparticles used in biomedical applications include liposomes, polymeric micelles, block ionomer complexes, dendrimers, inorganic and polymeric Nanoparticles, nanorods and quantum dots. All have been tested pre-clinically or clinically for targeted drug and gene delivery and as agents to enhance diagnostic imaging output like in MRI [9-11]. Properties present only on the nanoscale level, like the increased intensity of fluorescent light emission of semiconductor crystals (quantum dots) or switchable magnetic properties of superparamagenetic Nanoparticles (SPIONs), make these materials unique and useful for applications in the biomedical field of medical imaging and cell tracking. Other Nanoparticles like water-soluble synthetic polymers (dendrimers) were tested in pre-clinical models for the delivery of drugs, genes, and as imaging agents showing a rich versatility for tailoring their binding properties to several requirements, among them facilitation of cellular uptake of drugs (e.g. cancer drugs) [12-14]. The present review details the recent developments of beneficial application of nanoparticles in medical field.

2. Nanoparticles as Vaccines

A strong immune response was created by treating it inside animal noses with a "nanoemulsion" a suspension of alcohol, oil, soybean and surfactant to create droplets of 200 to 300 nanometrers in size. The oil particles can be used as key particle to react with protein and initialize an immune response which fights off infection. It disrupts the use of needles in addition to this it has other advantages, which can be use where refrigeration is not available. The method of using athrax vaccine may result in spreading of anthrax microbes by terrorist. Thus researches conclude that nasal nanoemulsion if it proves to be an ideal vaccine in humans it can be give to patients exposed to anthrax attack. Vaccines which are given after the exposure are used to boost the speed the immune response.

3. Role of Silver Nanoparticles as Anti-Microbial Agent

In general, the silver nanoparticles have positive charge which results in the attraction of negatively charged molecules. Silver nanoparticles plays it role as Anti-microbial as well as anti-bacterial agent. Particle size is very important because smaller the particle size greater the surface area which leads to higher inter-action with the bacteria. Microbes are found everywhere and they are dangerous to human body because of the existence of antibiotic resistant microbes. So that nanoparticles are being used to cease the effect of microbes they are used in the "prevention of bacterial colonization on surface of prostheses, catheters, dental materials and food processing surfaces such as stainless steel [15]. One of the above mentioned use is that using silver nanoparticles for preserving or keeping food fresher for longer period of time. Container with silver nanoparticle can be used to store fruits, vegetables, herbs, breads, cheeses, soups, sauces and meats which enriches and maintains the flavor, texture and nutrional value of the food compared to conventional container, the growth of harmful bacteria is much more reduced in container having silver nanoparticles these inhibiting microbe reproduction with silver nanoparticles decreases the harm that microbes can cause to humans this can lead to more sterilized environment that could otherwise be overlooked and result in harm.

4. Role of Ph Responsive Nanoparticles for Targeted Drug Delivery

One application of nanoparticles in medicine currently being developed involved employing nanoparticles to deliver drugs, heat, tight or other substances to specific types of cells (such as cancer cells) particles are engineered so that they are attracted to diseased cells, which allows direct treatment of those cells this technique reduce damage to healthy cells in the body and allows for earlier detection of disease. Nanotechnology offers here another challenge to come to this goal a bit closer, to deliver the drug in the right place at right time [16]. A key area in drug delivery for specific parks of the body is very important for the diagnosis of certain medical ailments. Despite, the drug targeting system is difficult without invasive treatment. PH responsive nanoparticles may be the best way to disrupt the invasive treatments at these target sites. These nanoparticles play a vital role in targeting multiple organization of the body such as (tissue, organs, sub-celllular compartments) [17]. The targeting multiple levels of organization results in treating a wide range of disease such as cancer and diabetes.

Nanoparticles which are defined as Engineered structure with diameter of < 100nm are devices and system which are produced by certain physical or chemical processes having appropriate properties. In Ph responsive nanoparticles which are about 130-330nm in size were designed in a way to react "physico-chemical changes to the material structure and surface characteristics when expose to PH Stimuli [17] the alteration in the structure and surface characteristics will protect a drug when travelling through highly acidic areas such as stomach. Ph responsive nanoparticle can be used at cellular level for intra-cellular delivery of certain drugs for the treatment of tumours. Nanoparticles lead to an increase in osmotic pressure, when it absorbs protons at endosomal Ph. On the whole, Ph responsive nanoparticle targets the affected cells and delivers drugs with high selectivity. This could allow a more accurate targeting of the site of interest

5. Nanoparticles in Stem Cell Therapy

Nanoparticles have advantages over today's therapy because to have certain properties or to behave in certain way. Nanoparticles have been used successfully by chemical engineers to enhance stem cells ability to regenerate the damaged vascular tissue and reduced muscle degeneration in mice. This allows the use of nanoparticles in gels, paints, polymers composites and high tech foams, living cells. Many researches have been done to find sticking power and finally the paper entitled "Interaction of nanoparticles with ideal liquid-liquid interfaces" published in physical reviewed molecular stimulation of the interaction between a non charged nanoparaticles and an "ideal liquid-liquid interface". They were excited to see that very small nanoparticles (of around 1 to 2 nanometres) have the ability to stick to interfaces. It had taken 50 percent more energy to dislodge for small particles sizes.

6. Gold Nanoparticles for the Treatment of Cancer

Cancer being killer disease researchers is looking for a cure to treat it. Cancer cells along with other organisms such as bacteria, viruses and DNA can be damaged by a technique like nanophotothermolysis with lasers and gold Nanoparticles. Gold Nanoparticles are probes for application in biomedical field because they can be easily prepared unlike other fluorescent probes (cancer) it is an invasive because one cell left over can lead to the regrow. The nanoparticles will create bubbles in contact with cell due to extreme temperature change. These bubbles burst sending out the shockwaves which damages and causes them to lyse. This technique allows selecting only the cancer cells or abnormal cells. However this technique has less efficiency in case of solid tumor, bones, and theroscelerotic plaques [18]**.** According to Letfullin et al [18] the altitude of this technique has reached due to laser wavelength, pulse duration, particle size and particle shape. Thus this technique leads to the increase in life span of human lives.

7. Role of Respirocyte in Human

Nanotechnology has also enabled the improvement of biochips, biofluids (for handling DNA and other molecules), and has a role in green manufacturing (e.g., biocompatibility and biocomplexity areas). An exploratory area for nanotechnology includes research into the condition and/or repair of the brain and other areas for regaining cognition. It may also find application in designing pharmaceuticals as a function of patient genotypes and in applying chemicals to stimulate production as a function of plant genotypes. Medical diagnosis with appropriate and effective delivery of pharmaceuticals is the medical areas where nanosize particles have found practical applications [19].

Nanodevices in medical sciences could function to replace defective or improperly functioning cells, such as the respirocyte proposed by Freitas [20]. This man-made red blood cell is theoretically capable of providing oxygen more effectively than an erythrocyte. It could replace defective natural red cells in blood circulation. Primary applications of respirocytes may involve transfusable blood substitution, partial treatment of anaemia, prenatal/neonatal problems, and lung disorders. The production of implantable detectors could be aided by nanotechnology with minimal quantities of blood. By employing this technology it should be possible to develop methods that use saliva instead of blood for the detection of illnesses or that can perform complete blood testing within a short period of time. It has been reported that nanomachines could administer drugs within a patient's body. Such nanoconstructions could deliver drugs to peculiar sites making treatment more accurate and precise [21]. Similar machines with specific 'weapons' could be used to remove obstacles in the circulatory system or in the identification and killing of tumour cells. Complete dentition replacement was done by recreating dental enamel, the hardest tissue in the human body, using highly organized micro architectural units of nanorods.

8. Nanodiagnostics

Nanodiagnostics devices can be used for early disease identification at the cellular and molecular levels. Nanomedicine could increase the efficiency and reliability of *in vitro* diagnostics, through the use of selective nanodevices to collect human fluids or tissue samples and to make multiple analyses at the sub cellular level. From an *in vivo* perspective, nanodevices might be inserted into the body to identify the early presence of a disease, or to identify and quantify toxic molecules, tumor cells, and so forth [22].

9. Functional Nanorobots in heart surgery and Dentistry

The other vital application of nanotechnology in relation to medical research and diagnostics are nanorobots. Nanorobots, operating in the human body, could monitor levels of various compounds and record the information in the internal memory. They could be quickly used in the examination of a given tissue, surveying its biochemical, biomechanical, and histometrical features in greater detail. Nanorobots are effectively employed for removing the heart blocks in more effective and accurate manner Dentifrobots might use specific motility mechanisms to penetrate human tissue with navigational precision, acquire energy, and sense and manipulate their surroundings in real time. An onboard nanocomputer that executes preprogrammed instructions in response to local sensor stimuli could be utilized to control the nanorobot functions. Also, the dentist could issue strategic orders directly to the nanorobots *in vivo* via acoustic signals. Nanorobotic dentifrices, when delivered either by mouthwash or tooth paste, can cover all subgingival surfaces, thereby metabolizing trapped organic matter into harmless and odorless vapors. Properly configured dentifrobots can identify and destroy pathogenic bacteria that exist in the plaque and elsewhere. These invisibly small dentifrobots are purely mechanical devices that safely deactivate themselves when swallowed [23].

10. Carbon Nanotubes as Nanoparaticles for Orthopaedic Implants

Nanoparticles may prove effective tools for improving orthopaedic implants. In our day today life orthopaedic implants are used in many surgical procedure to achieve better quality of life and to replace the damage bone or joint everything has a drawback likewise, orthopaedic implant can result in loosening of the implant failures and complicated revision surgeries according to spear and Cameron [24]. Carbon nanotubes of length 0.7-100 mm can be used to increase the lifespan of implant, carbon nanotubes have been used in two branches of bone and tissue engineering this helps to create mechanical reinforcement for composites and ceramics which are used as implants and coating to improve their bioreactivity (spear and Cameron 2008). By using the mechanical reinforcement the implants can withstand the day to day pressure. Overall a stable implant has been created the production of nanotubes by coatings and composites may be a challenge because it bigger an immune response which will limit the characteristic feature of the implant. Thus carbon nanotubes as orthopaedic implants are still being researched and its aptitude will reach with positive results in bone and tissue engineering.

11.Nanoneedles and Nanocomposite

Nanoneedle-based delivery is a powerful new tool for studying biological processes and biophysical properties at the molecular level inside living cells. Nanoneedles can be used as electrochemical probes and as optical biosensors to study cellular environments, stimulate certain types of biological sequences, and examine the effect of nanoparticles on cellular physiology. Nanosized stainless-steel crystals incorporated into suture needles have been developed. Cell surgery may be possible in the near future with nanotweezers, which are now under development.

Microfillers in composites and microcore materials have long been in use. Although the filler particle size cannot be reduced below 100 nm, Nanocomposite particles are minute enough to be synthesized at the molecular level. These nanoparticles improve the compressive strength of the material. Filler particles of submicron size, such as zirconium dioxide, are also necessary to improve polish ability and esthetics. However, when particles of this size are used, the material may be more prone to brittleness and cracking or fracturing after curing. Hence, we need a hybrid composites and composites containing a wider distribution of filler particles. Although these composites display a better balance of strength and esthetics, they are weak due to nanoparticle clumping or agglomeration. This problem can be overcome by incorporating a proprietary coating process during the particle manufacturing procedure, thereby eliminating weak spots and providing consistent strength throughout the entire "fill" of the core build-up. Additionally, the even distribution of nanoparticles results in a smoother, creamier consistency and improves flow characteristics. Once the material is cured to its hardened state, these properties contribute to the dentin-like cutability and polishability of the material [25].

Bone is a natural nanostructure that is composed of organic compounds (mainly collagen) and reinforced with inorganic ones. Nanotechnology aims to emulate this natural structure for orthopedic and dental applications and, more particularly, for the development of nanobone. Nanocrystals show a loose microstructure, with nanopores situated between the crystals. The surfaces of the pores are modified such that they adsorb protein, due to the addition of silica molecules. Bone defects can be treated by using these hydroxyapatite nanoparticles [25].

12.Quantum Dot

Recent studies have considerable interest in developing these quantum confined nanocrystals as fluorescent probes for biomedical applications. Semiconductor QDs offer several advantages, such as size- and composition-tunable emission from visible to infrared wavelengths, large absorption coefficients across a wide spectral range, and very high levels of brightness and photostability. They are nontoxic to cells and animals and can be used as anticancer agents. Quantum Dot with nanodots of a specific colour are believed to be flexible and could offer a cheap and easy way to screen a blood sample for the presence of a number of different viruses at the same time. It could also give physicians a fast diagnosis tool to detect, say, the presence of a particular set of proteins that strongly indicates the onset of myocardial infarction.

13. Biosensors

A biosensor can be defined as any piece of hardware that interacts with a biological or physiological system to acquire a signal for either diagnostic or therapeutic purposes. The data gathered using biosensors are then processed using biomedical signal processing techniques to facilitate human or automated interpretation. Recent days cell phones are used to both monitor and transmit biomedical signals. Pulse oximetry which is used to monitor blood oxygen levels now can be used in real time wireless communication at low cost to provide oximetry even outside the hospital. Biosensor technology incorporates a wide range of devices from basic stethoscope, thermometer to sophisticated PET scanners, MRI and ultrasound machines.

14. Bio Medical Imaging

Biomedical imaging involves capture of images for both diagnostic and therapeutic purposes. This technology utilize either x-rays (CT Scans), Sound (Ultrasound), Magnetism (MRI), radioactive pharmaceutical (SPECT, PET) or light (endoscopy, OCT) to assess the current condition of an organ or a tissue and to monitor the patient at time intervals for effective diagnosis and treatment. Optical molecular imaging is widely used to image human cells and molecular without the need for a biopsy or cell culture. Cancer can be spotted before they render their effects at the level of gross pathology. Optical coherence tomography (OCT) constructs image from light that is transmitted and scattered through the body.

15. Biomedical Image Processing

It includes the analysis, enhancement and display of images captured via x-ray, ultrasound, MRI, nuclear medicine and optical imaging techniques. Image reconstruction and modeling techniques allow instant processing of 2D signals to create 3D images. Computerized algorithms can provide temporal and spatial analysis to detect patterns and characteristics indicative of tumors and other ailments.

16.Biomedical Signal Processing

It involves the analysis of these measurements (Heart rate, blood pressure, oxygen saturation levels, blood glucose, nerve conduction, brain activity etc) to provide useful information upon which clinicians can make decisions. Engineers discover new ways to process these signals using a variety of Mathematical formulae and algorithms. Working with traditional bio-measurement tools, the signals can be computed by software to provide physicians with real time data and greater insights to aid in clinical assessments. Signal processing helps to determine the state of a patient's health through more non invasive measures. Real time monitoring of disease leads to better management of chronic conditions, earlier detection of adverse events like heart attacks and strokes and earlier diagnosis of disease. Biomedical signal processing is especially useful in the critical care setting, where patent data must be analyzed in real time.

17.Cloud Computing

It takes real time monitoring one step further, to provide advanced specialist support for rural and remote communities. Remote database system is useful in telemedicine applications. Real time embedded signal processing could be programmed on to chips that are part of small lightweight devices integrated into cell phones or worn by patients who can be monitored from home.

18. Conclusion

Nanoparticles present highly attractive applications in the field of medicine. In order to successfully prepare and biofunctionalise Nanoparticles for a given biomedical application, a wide range of physical, chemical, biological and physiological factors and conditions must be taken into account. Despite Nanoparticles are being employed in latent fingerprints. Thus field of nanomedicine is new and growing rapidly. Nanoparticles are being used in many branches of science and medicine. The articles examined in this review were only examples of their possible medical applications in emussing life.

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