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Study of Nanoparticles and Their Multiple Applications for Human Health

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Abstract:

Magnetic particles may be used to selectively attach and manipulate or transport targeted species to a desired location under the influence of an external magnetic field. use of magnetic nanoparticles will be discussed, namely, in magnetic liquids for densimetric separation, in therapeutic and diagnostic testing Ever since the origin of life, communication in one form or the other was there in the history. Even the minute form of life such as bacterium and fungi are communicating, though the mechanism is different. There was an earlier saying that history cannot be changed. But the technology especially nanotechnology makes the revolutions in the history. Nanomedicine involves utilization of nanotechnology for the benefit of human health and well being. The use of nanotechnology in various sectors of therapeutics has revolutionized the field of medicine where nanoparticles of imensionsranging between 1 - 100 nm are designed and used for diagnostics, therapeutics and as biomedical tools for research1. It is now possible to provide therapy at a molecular level with the help of these tools, thus treating the disease and assisting in study of the pathogenesis of disease. Conventional drugs suffer from major limitations of adverse effects occurring as a result of non specificity of drug action The biological effects of traditional medical-based hyperthermia such as microwave, RF and ultra sound, have been described, quantified and compared in terms of Cumulative Equivalent Minute (CEM) from Arrhenius models. Various nano systems, as a result of their larger size, are accumulated at higher concentrations than normal drugs. In addition, the increased vascular permeability coupled with an impaired lymphatic drainage in tumors allows an enhanced permeability and retention.

Keywords:-Nanotechnology, Nanoelectronics, Carbon-nanotube, Magnetic-nanoparticles Nanomedicin, Quantum dots, nanopores

I. INTRODUCTION

The world is on the brink of a new technological revolution beyond any Human experience. A new, more powerful industrial revolution capable of bringing wealth, health and education, without pollution, to every person on the planet Nanotechnology provides unprecedented technological solutions to many health problems cleaner production. One area of nanotechnology application that holds the promise of providing great benefits for society in the future is in the realm of medicine [1, 3]. Nanotechnology is already being used as the basis for new, more effective e drug delivery systems and is in early stage development as in regeneration research [4, 6].Magnetic particles may be used to selectively attach and manipulate or transport targeted species to a desired location under the influence of an external magnetic field [7, 11].Use of magnetic nanoparticles will be discussed, namely, in magnetic liquids for densimetric separation, in therapeutic and diagnostic testing [12]. Ever since the origin of life, communication in one form or the other was there in the history. Even the minute form of life such as bacterium and fungi are communicating, though the mechanism is different [13, 15]. There was an earlier saying that history cannot be changed. But the technology especially nanotechnology makes the revolutions in the history. Nanomedicine involves utilization of nanotechnology for the benefit of human health and well being. The use of nanotechnology in various sectors of therapeutics has revolutionized the field of medicine where nanoparticles of imensionsranging between 1 - 100 nm are designed and used for diagnostics, therapeutics and as biomedical tools for research1[16]. It is now possible to provide therapy at a molecular level with the help of these tools, thus treating the disease and assisting in study of the pathogenesis of disease. Conventional drugs suffer from major limitations of adverse effects occurring as a result of non specificity of drug action. There is no present and future, the development was such like a dream come true when one gets up from the sleep. In communication sector always the major factor was the medium [17, 18]. The change was so rapid that no one realized when the pigeon has become electrons. It is really thought provoking that how nanotechnology brings out revolutions in telecommunication as well as computing and networking industries and lack of efficacy due to improper or ineffective dosage formulation (*e.g.*, cancer chemotherapy and antidiabetic agents [19]. Designing of drugs with greater degree of cell specificity improves efficacy and minimizes adverse effects. Diagnostic methods with greater degree of sensitivity aid in early detection of the disease and provide better prognosis. Nanotechnology is being applied extensively to provide targeted drug therapy, diagnostics, tissue regeneration, cell culture, biosensors and other tools in the field of molecular biology. Various nanotechnology platforms like fullerenes, nanotubes, quantum dots, nanopores, dendrimers, liposomes, magnetic nanoprobes and radio controlled nanoparticles are being developed. Forthcoming developments in nanotechnology through which the impossible can be made possible are nonmaterial's with novel optical, electrical, and magnetic properties, compact as well as fast non-silicon based chipsets for processors, quantum computing and DNA computing, development of telecom switches which are fast and reliable, micro-electro-mechanical systems and above all the development of imaging and microscopic systems with high resolution. So for these reasons it is not futile to examine the broad range of nanotechnology and the revolutions made by it in the field of telecommunications [20, 21]. Nanotechnology is not a single technology or discipline, but it encompasses various technologies that cross sectors, such as nanomaterials (NMs), medicine, devices, fabrication, electronics, communications, and energy [22]. It is the ability to measure and to control matter at the nanometres scale. Hence a detailed account of the types of communications and the recent development in this field is essential. Development of newer drug delivery systems based on nanotechnology methods is being tried for conditions like cancer, diabetes, fungal infections, and viral infections and in gene therapy [23]. The main advantages of this modality of treatment are targeting of the drug and enhanced safety profile. Nanotechnology has also found its use in diagnostic medicine as contrast agents, fluorescent dyes and magnetic nanoparticles [24]. Properties and structures at the nanoscale, often involving dimensions that are just tiny fractions of the width of a human hair. Nanotechnology is already being used in products in its passive form, such as cosmetics and sunscreens, and it is expected that in the coming decades, new phases of products, such as better batteries and improved electronics equipment, will be developed and have far-reaching implications. Nanotechnology medical developments over the coming y ears will have a wide variety of uses and could potentially save a great number of lives. Nanotechnology is already moving from being used in passive structures to active structures, through more targeted drug therapies or "smart drugs." These new drug therapies have already been shown to cause fewer side effects and be more effective than traditional therapies. Or replacement of body parts that are currently lost to infection, accident, or disease. These predictions for the future have great significance not only in encouraging nanotechnology research and development but also in determining a means of oversight The biological effects of traditional medical-based hyperthermia such as microwave, RF and ultra sound, have been described, quantified and compared in terms of Cumulative Equivalent Minute (CEM) dosesderived from Arrhenius models. A new method of hyperthermia delivery , achieved through the excitation of magnetic nanoparticles (mNP) by alternating magnetic fields (A MF), requires a different method of delivery , dose calculation , and dose and effect quantification[25] .The primarily difference in convention medical hyperthermia and mNP hyperthermia is the delivery of energy (heat) in every localized manner .

II. ELECTRONIC COMMUNICATION AND INFORMATICS

Electronic communication can be defined as a communication by means of guided or unguided electromagnetic energy or both. Or it is a general term describing all forms of communication via electronic means such as internet, facsimile, satellite, cable, television, computers, networks, etc.The sudden leap to the nano regime will result in single-molecule and single-electron based transistors. And special devices can be made out of these kinds of transistors Improvements in communication and informatics. Nanotechnology interphased with biological, physical and chemical sciences can bring much faster and powerful information handling equipments.

Nanotechnology In Electronic Communication and DNA Analysis

Communication inside the body is happening in two ways.

i) Natural triggering - such as reflex action, antibody generation etc. where the neurons are the carriers for the information transfer.

ii) Induced triggering – such as targeted drug delivery and isotropic activation analysis where the nano materials are having very significant role, where as in first case bio macro molecules are playing the significant role. In isotropic activation analysis a particular isotopic substitution will be responsible for the communication. The medium of communication will be always an aqueous system inside the body. Hence not only the size but shape also matters. Nano devices to be used in vivo should be designed in such a way that there will be minimum amount of friction. Even though nanotechnology is in its infancy, scientists & technologists will make use of it in all phases of life like never before. In future, they hope to mould quantum dots to track specific chemical reactions inside nuclei, such as how proteins assist repair DNA after irradiation. They have already visualized the 'dots' journey from the area surrounding the nucleus to inside the nucleus, an achievement that opens the door for real-time scrutiny of nuclear trafficking mechanisms. They also anticipate targeting other cellular organelles as well the nucleus, such as mitochondria and Golgi bodies. Since, quantum dots emit different colours of light based on their size; they can be used to observe the transfer of material between cells.

Advantages of Drug Delivery to Disease Sites with Nanotechnology

The pathophysiological condition and anatomical changes of diseased or inflamed tissues offers many advantages for the delivery of various nanotechnological products. Drug targeting can be achieved by taking advantage of the distinct pathophysiological features of diseased tissues. Actually, the physiology of diseased tissues may be altered in a variety of physiological conditions and can be exploited for passively targeting of drugs. Thus, it exploits the anatomical differences between normal and diseased tissues to achieve site-specific and targeted delivery of drugs. Nanotechnological products thus have an advantage over other normal drugs. An ideal targeting system should have long circulating time, it should be present at appropriate concentrations at the target site, and it should not lose its activity or therapeutic efficacy while in circulation. Various nanosystems, as a result of their larger size, are accumulated at higher concentrations than normal drugs. In addition, the increased vascular permeability coupled with an impaired lymphatic drainage in tumors allows an enhanced permeability and retention effect of the nanosystems in the tumors or inflamed tissues. The nanosystems and their selective localization in the inflamed tissues. The tendency of nanosystems to specifically localize in the reticuloendothelial system also presents an excellent opportunity for passive targeting of drugs to the macrophages present in the liver and spleen. Thus, this natural system can be used for targeting drugs for intracellular infections. The blood-brain barrier is a unique membrane that tightly segregates the brain from the circulating blood. Thus, drug delivery to this organ is a challenge, because the brain benefits from very efficient protection. Nanotechnology offers a solution for using the numerous chemical entities for treating brain disorders that are not clinically useful because of the presence of the blood-brain barrier. Nanoparticles can be effectively used to deliver relevant drugs to the brain. Drug loading onto nanoparticles modifies cell and tissue distribution and leads to a more selective delivery of biologically active compounds to improve drug efficacy and reduces drug toxicity. Thus, various nano systems can be successfully used as new drug carriers for brain delivery.

III. CARBON-NANOTUBE

Carbon nanotubes discovered in 199134 are tubular structures like a sheet of graphite rolled into a cylinder capped at one or both ends by a buckyball. Nanotubes can be single walled carbon nanotube (SWCNT) or multiwalled carbon nanotube (MWCNT) in concentric fashion. Single walled nanotube has an internal diameter of 1-2 nm and multiwalled carbon nanotube has a diameter of 2-25 nm with 0.36 nm distance between layers of MWCNT. These vary in their length ranging from 1 μm to a few micrometers. These are characterized
by greater strength and stability hence can be used as stable drug carriers. Cell specificity can be achieved by conjugating antibodies to carbon nanotubes with fluorescent or radio labelling. Entry of nanotubes into the cell may be mediated by endocytosis or by insertion through the cell membrane. Carbon nanotubes can be made more soluble by incorporation of carboxylic or ammonium groups to their structure and can be used for the transport of peptides, nucleic acids and other drug molecules. Carbon nanotubes are being investigated for killing cancer cells selectively. Has shown increased drug delivery to the interior of cells compared to. The efficacy of amphotericin B nanotubes was greater as an antifungal agent compared to amphotericin B alone and it was effective on strains of fungi which are usually resistant to amphotericin B alone. Further, there was reduced toxicity to mammalian cells with the ability of nanotubes to transport DNA across cell membrane is used in studies involving gene therapy. DNA can be attached to the tips of nanotubes or can be incorporated within the nanotubes compared to transfer of naked DNA. This confers the advantage of non immunogenicity in contrast to viral vectors used for gene transfer. Gene silencing studies with small interfering RNA (siRNA) have been done as a modality of cancer therapy where tumour cells will be selectively modulated. Functionalized single walled carbon nanotubes can be used with siRNA to silence targeted gene expression. It was observed that carbon nanotubes, except acetylated ones, when bonded with a peptide produce a higher immunological response compared to free peptides. This property can be used in vaccine production to enhance the efficacy of vaccines. Further, it was also found that compounds bound to nanotubes increase the efficacy of diagnostic methods like. These can also be used for designing of biosensors owing to property of functionalization and high length to diameter aspect ratio which provides a high surface to volume ratio. Water insoluble forms of nanotubes like pristine carbon nanotubes have high *in vitro* toxicity compared to modified water dispersible forms of nanotubes. It was also seen that the toxic potential decreases with functionalization. Further, functionalization also affects the elimination of the nanotube. SWCNTs without conjugation to monoclonal antibody have a high renal uptake and modest liver uptake as compared to SWCNTs with conjugation to monoclonal antibody having higher liver uptake and lower renal uptake, Carbon nanotubes are long carbon-based tubes that can be either single- or multiwalled and have the potential to act as biopersistent fibers. Nanotubes have aspect ratios >100, with lengths of several mm and diameters of 0.7 to 1.5 nm for single-walled carbon nanotubes (SWCNT) and 2 to 50 nm for multiwalled carbon nanotubes (MWCNT). In vitro incubation of keratinocytes and bronchial epithelial cells with high doses of SWCNT results in ROS generation, lipid peroxidation, oxidative stress, mitochondrial dysfunction, and changes in cell morphology Recent studies with carbon derived nanomaterials showed that platelet aggregation was induced by both single and multi-wall carbon nanotubes, but not by the C60-fullerenes that are used as building blocks for these CNT MWCNT also elicit pro-inflammatory effects in keratinocytes Several studies using intratracheal instillation of high doses of nanotubes in rodents demonstrated chronic lung inflammation, including foreign-body granuloma formation and interstitial fibrosis In two in vivo studies SWCNTs were demonstrated to induce lung granulomas after intratracheal administration indicating that these nanotubes cannot be classified as a new form of graphite on material safety data sheets. On a dose per mass basis the nanotubes were more toxic than quartz particles well known for their lung toxicity.

IV. QUANTUM DOTS

Quantum dots are a heterogeneous group of nanoparticles Quantum dot absorption, distribution, metabolism and excretion, and therefore also quantum dot toxicity, depend on multiple factors derived from both inherent physicochemical properties and environmental conditions. Quantum dots may vary in size ranges from 2.5 up to 100 nm, depending on coating thickness. Studies specifically performed to investigate quantum dot toxicity are few In vitro studies have indicated that quantum dots may be toxic of which some toxicity could be attributed to the surface coating demonstrated that quantum dot toxicity was reduced after surface modification with N-acetylcysteine, while the non modified cadmium telluride quantum dots induced lipid peroxidation in the cells. Showed “naked” quantum dots to be cytotoxic by induction of reactive oxygen species resulting in damage to plasma membranes, mitochondria and nucleus. As it is the bioactive coating which allows the use of quantum dots for specific targeting to cells and/or cell organelles, attention is warranted in using the surface molecules in terms of induction of toxic effects. However, also the quantum dot core material has an effect on the toxic potential of the quantum dots as for cadmium containing quantum dots the toxicity was suggested to be due to release of highly toxic free Cd^{2+} ions For quantum dots composed of cadmiun/telluride cellular toxicity was found but not for cadmium selenium/zinc sulphate quantum dots. On the other hand Hardman also reported on studies demonstrating a lack of both in vitro and in vivo toxicity. However, before there can be a responsible development of quantum dots with minimal risks more information on toxicological risks needs to be provided.

V. GOLD NANOPARTICLES/NANOSHELLS

In the summary of evaluations performed by the Joint FAO/WHO (Food and Agriculture Organization of the United Nations/World Health Organization) Expert Committee on Food Additives (JECFA) gold was not considered to present a hazard when used as coloring agent and food additive However, such evaluations did not consider nanoformulations of gold. Metallic colloidal gold nanoparticles are widely used, can be synthesized in different forms (rods, dots), are commercially available in various size ranges and can be detected at low concentrations. Cells can take up gold nanoparticles without cytotoxic effects For biomedical applications, they are used as potential carriers for drug delivery, imaging molecules and even genes and for the development of novel cancer therapy products For gold nanorods the cytotoxicity could be attributed to the presence of the stabilizer CTAB of which even residual presence after washing resulted in considerable cytotoxicity. PEG-modified gold nanorods with removing the excess CTAB did not show cytotoxicity In an acute oral toxicity study no signs of gross toxicity or adverse effects were noted when a nanogold suspension (nanoparticle diameter ca. 50 nm) was evaluated, the single dose for acute oral LD_{50} being greater than 5000 mg/kg body weight. Gold solutions are also used to prepare nanoshells composed of gold and copper, or gold and silver to function as contrast agents in Magnetic Resonance Imaging (RMI) and gold-silica for photothermal ablation of tumor cells In vitro the non targeted nanoshells did not show cytotoxicity for the tumor cells, whereas after binding to the tumor cells cell death could be obtained after laser activation Also in vivo positive results were obtained with photothermal ablation therapy in a mouse model for colon carcinoma after nanoshells of approximately.

VI. CARBON NANOTUBE EMITTERS

Standard electron emitters are based either on thermionic emission of electrons from heated filaments with low work functions or field emission from sharp tips. The latter generates monochromatic electron beams; however, ultrahigh vacuum and high voltages are required. Further the emission current is typically limited to several micro amperes. Carbon fibers typically 7µm in diameters have been used as the electron emitters; however they suffer from poor reproducibility and rapid deterioration of the tip. Carbon nano tubes have high aspect ratios and small tip radius of curvature. The ability to emit electrons from the body of nano tubes was attributed to the small radius of the tubes and the presence of defects on the surface of carbon nano tubes (CNT).

VII. MAGNETIC NANOPARTICLES IN BIOLOGICAL OBJECTS

Long before the first magnetic nanoparticles have been synthesised, they were detected in natural biological complexes. It was found that magnetic nanoparticles play an important role in the metabolism and functioning of living organism. The magnetic nanoparticles found most often in living organisms are magnetite and ferrihydrite (the mineral core of ferritin).Magnetite-containing magnetisms are rather abundant and have been repeatedly observed by one-dimensional chain ensembles of magnetic nanoparticles of iron oxides ($Fe3O4$ with a g-$Fe2O3$ impurity) are present in the magnetic bacteria. The formation of inorganic nanostructures in biological systems occurs spontaneously on contact with a highly organised molecular matrix; it is highly reproducible as regards the particle shape and composition and takes place at nearly ambient temperatures (much below 100 8°C) and in the aqueous phase. These processes include a set of complex and not fully understandable reactions that substantially depend on the supramolecular organisation of particles and the structure of the organic matrix, which influences the nanoparticle nucleation and growth. For example, the bacterial protein Listeria innocua,having an inner cavity with a diameter of 5 nm, has been used to prepare the γ-Fe2o3 nanoparticles with a narrow size distribution (9.3 - 0.2 nm).Elucidation of the mechanism of bio mineralisation and their use for the development of new methods for the Synthesis of nanoparticles and the effective control of their composition, structure, size and morphology can form a rather promising approach in nanobiotechnology and in the development of new nanomaterials.The magnetic nanoparticles are found not only in bacteria but also in the cells of higher living organisms. It is considered that the anisotropic magnetite nanoparticles present in cells can interact with the Earth's magnetic pole and transfer information to other bio-receptors of the organism. Presumably, the stable space sense of many higher living organisms (for example, in the seasonal migration of birds and fishes) is related to their ability to locate themselves with respect to the Earth's magnetic field at each particular instant.Ferritin is the most abundant form of non-haem iron in living organisms and plants. Its major role is to preserve the biological reserve of iron. This water-soluble protein consists of an inorganic core with a diameter of ~7 nm and a protein shell with ~6 nm thickness. The core contains ~4500 Fe^{3+} ions as a hydrated oxide close in composition has $H2PO_3$ groups on the external surface. In terms of the type of magnetic structure, ferritin is an antiferromagnet; however, due to the incomplete compensation of magnetic moments of the two sub lattices, the ferritin core has a nonzero magnetic moment, like other magnetic nanoparticles of similar sizes. Ferritin itself exhibits super paramagnetic properties. Horse spleen ferritin is commercially available and has been comprehensively studied. Since natural ferritin mainly contains antiferromagnetic ferrihydrite with a relatively low magnetic moment as the core, modified magnetoferritin in which the ferrohydrate core has been replaced by a magnetite or maghemite core with a higher magnetisation is used more often for applied purposes The protein shell ensures the biocompatibility of ferritin and magneto ferritin particles. The synthetic polymer colloids containing magnetic nano-particles were first obtained in the mid-1970s. They have found application in biochemical experiments on the targeted interaction with cells and biologically active compounds, gene transfer and DNA extraction of considerable interest is the synthesis of inorganic magnetic nanoparticles using organised molecular structures analogous to biological systems. In particular, inclusion of magnetic nanoparticles into multilayer polyelectrolyte shells of latex particles containing glucose oxidase allowed the efficiency of these particles as nanobioreactors to be markedly increased due to the effective stirring of their colloid solution in the alternating magnetic field polymer systems and even single macromolecules are now widely used in nanotechnology for the formation of ordered ensembles of nanoparticles and nanostructures. The preparation of new organised planar complexes of amphiphilic polycations with DNA formed in a monolayer on the aqueous surface has been described In addition to individual quasi-linear DNA molecules, DNA complexes with a toroidal structure and complexes with planar, extended, and net-like structures were found on the monolayer surface. The monolayer and multilayer films formed on the basis of these complexes were used as nano-reactors for the synthesis of inorganic nanostructures. First, binding of Fe^{3+} cations from the aqueous phase took place followed by the formation of the inorganic phase in the presence of a reducing agent ($NaBH_4$ or ascorbic acid) at pH 9 - 10 in air. This gave superthin stable polymeric nanocomposite films incorporating DNA molecules and assembled quasilinear ensembles of 2 - 4 nm iron oxide nanoparticles (magnetite and maghemite) as structural units. The introduction of iron oxide nanoparticles into DNA complexes can be used to elucidate the role of iron ions in the change in the composition and magnetic properties of nucleoproteid DNA complexes at certain stages of the cell cycle. It has been reported that the magnetite nanoparticles formed upon mixing of Fe^{2+} and Fe^{3+} ions in the presence of DNA practically did not react with DNA. The corresponding DNA complexes with magnetite nanoparticles have been prepared by reduction (increase in the pH) of pre-synthesised DNA complexes with Fe^{2+} and Fe^{3+} ions. Magnetic nanoparticles can be used in the systems of targeted transfer of biologically active compounds and drugs (in particular, for the cancer therapy using the hyperthermic effect caused by magnetic heating in the detection, isolation, immobilisation and modification of biologically active compounds, cells and cell organelles, and as contrasting materials in magnetic resonance tomography. of particular interest is the synthesis of so called biocompatible magnetic nanoparticles, which is attained by modification and structurisation of their surface. A serious problem that can restrict the application of magnetic nanoparticles is their potential toxicity.

VII. CONCLUSIONS

Nanotechnology offers an extremely broad range of potential applications in communication sector. Even though it is not sure which pathway the nanotechnology can take and bring the fantasies real, it is certain that nanotechnology is penetrating into every aspects of our life and will make the world different from what we know now. This natural system can be used for targeting drugs for intracellular infections. The therapeutic value of many promising drugs for the treatment of various neurological disorders is diminished by the presence of the blood-brain barrier. The multidisciplinary field of nanotechnology is bringing the science of the almost incomprehensibly small device closer and closer to reality. The effects of these developments will at some point be so vast that they will probably affect virtually all fields of science and technology. As such, nanotechnology holds the promise of delivering the greatest technological breakthroughs in history. Over the next couple of years it is widely anticipated that nanotechnology will continue to evolve and expand in many areas of life and science, and the achievements of nanotechnology will be applied in medical sciences, including diagnostics, drug delivery systems, and patient treatment As sure as the sun rises each day, information and the technology behind it continue to flow and transform at breakneck speed. The impacts of the properties of nanoparticles for technological application can be easily adopted for measuring health-related properties such as size and concentration of in communication & Health sector.

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