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Nanorobotics in Nano Drug Delivery

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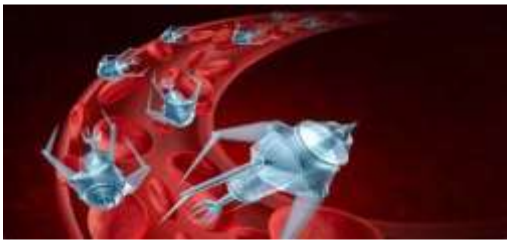
ABSTRACT—

Nanorobotics is a new area of research that has the potential to improve the delivery of drugs to specific areas of the body. Nanorobots are very small devices that can be programmed to carry drugs to specific cells or tissues, which could make drugs more effective and reduce side effects. One of the benefits of using nanorobots is that they can be equipped with sensors that detect changes in their environment, which means that drugs can be released exactly when and where they are needed. However, there are challenges associated with the use of nanorobots, including making sure that they are safe and can be cleared from the body. Overall, researchers are working hard to develop safe and effective nanorobots that can be used to deliver drugs more precisely and with fewer side effects.

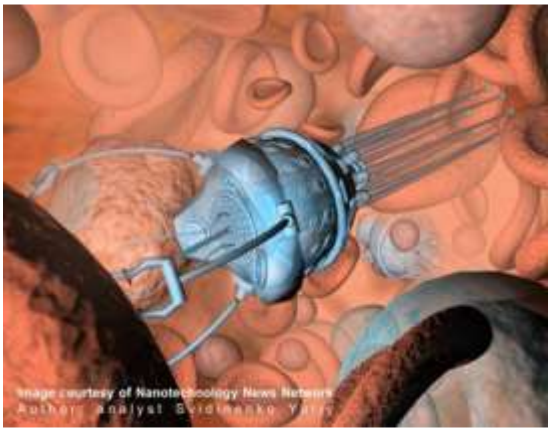
Keywords—nanorobotics, nanodrug delivery, targeted drug delivery, biocompatibility.

Introduction

This Nanorobotics is an emerging field that has the potential to transform the way we deliver drugs in medicine. These tiny robots can be programmed to perform specific tasks, such as delivering drugs directly to the cells or tissues that need them. This approach can be more effective and less harmful than traditional drug delivery methods. Nanodrug delivery is an important area of research because it can improve the efficacy of drugs and reduce side effects. Nanorobots can be designed to detect diseases, monitor physiological parameters, and deliver drugs.



One of the advantages of using nanorobots is the ability to achieve real-time monitoring and feedback. This means that drugs can be released at the right time and place, making them more effective and reducing side effects. However, there are challenges associated with using nanorobots in drug delivery. Safety is a major concern, and nanorobots must be biocompatible and non-toxic. Technical challenges also exist in designing and manufacturing nanorobots that can perform the desired functions. Despite these challenges, the potential benefits of using nanorobots in drug delivery are significant. Researchers are working hard to develop safe and effective nanorobots that can improve the delivery of drugs in medicine. In this paper, we will explore the use of nanorobotics in nanodrug delivery, including the benefits and challenges associated with this technology.



STRUCTURE OF NANOROABOT

Doctors today can't affect molecules in one cell while leaving identical molecules in a neighboring cell untouched because medicine today cannot apply surgical control to the molecular level.to understand what nanotechnology can do for medicine, we need a picture of the body from a molecular perspective. ...ongoing developments in molecular fabrication, computation, sensors and motors will enable the manufacturing of nanobots.

One of the most promising applications of nanotechnology is that of drug delivery, and in particular the targeted delivery of drugs using nano structures. Designing a drug delivery system is challenging in terms of targeting the drug to specific sites. Research into the rational delivery and targeting of pharmaceutical, therapeutic, and diagnostic agents is at the forefront of projects in nanomedicine.

Mononuclear phagocytes, dendritic cells, endothelial cells, and cancers (tumor cells, as well as tumor neovasculature) are key targets.

In the last decade, progress in developing nano sized hybrid therapeutics and drug delivery systems has been remarkable. It is essential that benefits of genomics and proteomics research and advances in drug delivery, are quickly harnessed to realize improvements in diagnosis and therapy. Considering the properties of nanobots to navigate as blood borne devices, they can help important treatment processes of complex diseases in early diagnosis and smart drug delivery.

Hydrogel-embedded gold nanorods activated by plasmonic photothermy with potent antimicrobial activity, Nanomedicine: Nanotechnology

Gold nanorods have strong absorption bands in near-infrared (NIR) light region and show photothermal effects. Since NIR light can penetrate deeply into tissues, their unique optical, chemical, and biological properties have attracted considerable clinical interest. In this review, we discuss current progress using gold nanorods as bioimaging platform, phototherapeutic agents, and drug delivery vehicles. Gold nanoparticles are highly promising metals in biomedical applications because of their unique optical, chemical, and biological properties. The importance of gold nanoparticles in biomedical applications derives from their tunability of optical properties depending on their sizes and shapes. Because of the capability of gold nanoparticles to bind a wide range of organic molecules, their low cytotoxicity, and their strong and tunable optical absorption, the combination of biological molecules and pharmaceutical products with gold nanoparticles is becoming an increasingly popular theme in biomedical fields.Depending on their size and shape, gold-based nanoparticles have additionally unique optical properties for the interaction with light such as strong absorption and scattering in the visible-near-infrared (NIR) region.These properties support gold nanoparticles as good candidates for bioimaging agents. Bioimaging, therapeutic application, and controlled delivery of bio functional molecules using a type of gold nanoparticle known as gold nanorods. this avoids aggregation of gold nanorods in water via electrostatic repulsion. Gold nanorods have an extinction band originating from light scattering and absorption at the NIR region. Light scattering from the gold nanorods was detected in the cells. Since gold nanorods have stronger absorption than contrast agent, the distribution of gold nanorods can be observed by X-ray CT.42 Bioimaging is one of the most striking applications [1].

Nanorobotics: a novel and conceptual technique for drug delivery system and its applications in pharmaceuticals.

Nanorobotics is the futuristic aspect of nanotechnology which is utilized in various sectors like Engineering, Medical Science, Pharmaceuticals. Nanorobots would be constitute of any active or passive structure (Nano scale) capable of actuation, sensing, information processing, intelligence, swarm behaviour at nano scale. There are some of the characteristics abilities that are desirable for a nanorobot to function are: • Swarm Intelligence-decentralization and distributive intelligence • Cooperative behaviour-emergent and evolutionary behaviour •Self assembly and replication-assemblage at nano scale and "nano maintenance" • Nano Information processing and programmability-for programming and controlling nanorobots (autonomous nanorobots) • Nano to macro world interface architecture-an architecture enabling instant access to the nanorobots and its control and maintenance They are generally invisible to naked eye, which makes them hard to manipulate and work with Techniques like scanning electron microscopy (SEM) and Atomic Force Microscopy (AFM) are being employed to establish a visual and haptic interface to enable us to sense the molecular structure of these nanosized devices. Elements of nanorobotics Carbon will likely be the principal element comprising the bulk of a medical nanorobot, probably in the form of diamond or diamond/fullerene nanocomposites. Due to the extremely high surface energy of the passivated diamond surface and the strong hydrophobicity of the diamond surface, the diamond exterior is almost completely chemically inert.Medical nanorobots can be of great importance in easy and accurate correction of genetic defects, and help to ensure a greatly expanded health span.More controversially, medical nanorobots might be used to enhance natural human capabilities. Biochip The joint use of nanoelectronics, photolithography, and new biomaterials, can be considered as a possible way to enable the required manufacturing technology towards nanorobots for common medical applications, such as for surgical instrumentation, diagnosis and drug delivery [2].

Nanobots: development and future

Nanodips and nanobots for curing heart diseases. the scientist Eric Drexler, inspired by the talk, published his book "Engines of Creation", where genetically programmed molecular machines were mentioned as upcoming technologies in cellular biology.3 The first study related to nanobots was made by Robert Freitas.4 It was related to medical nanobots called respirocytes; resembling red blood cells.4 Nanobots could be defined as a controllable nanoscale machine composed of a sensor and a motor, capable by performing specific tasks.5 These are not comparable to a drone, instead are more similar to a complex piece of fabric.6 Robert Wood defined them as devices that detect friends or enemies; undergoing through a conformational change when they sense an enemy, catalyzing the release of a substance that can act against it.6Nanobots properties Nanobots can be produced using organic materials such as proteins and polynucleotides, or inorganic materials such as metals or diamond. In the case of diamond, this stands out for its high strength and high performance.Because of these determinant tasks (detect and mobilize), two devices can be identified as essential: sensors and propulsion equipment; and from this information it can be deduced some other devices will be needed as well, like power supplies and molecular computers, without excluding devices to develop a specific task like storage compartment or manipulators. Sensor are one of the most important parts in nanobots. Mechanical, thermal, optical, magnetic, chemical and biological sensors have been tested in nanobots applications.14 Any sensor that uses a nanoscale phenomenon for its operation is classified as a nanosensor.14 On the organic part, biosensors utilize biological reactions for detecting target analytes,16 and considering the need to accomplish the target treatments goals of nanobots in medicine, this type of sensors are the most evident devices to explore in the field of nanorobotics. This system utilizes biological material that will be attached by itself to a coated cantilever, causing fundamental changes in mass or its surface tension.17However, in general terms, sensors provide two functions to the surface, detecting the presence of the target molecules and indirectly know the amount of damage that exists from the change in the functional properties of nanobot. Therefore, many types of sensors were developed in function of the target molecules that are wanted Int J Biosen Bioelectron ,Currently, utilizing the AFM as an effector, nanocantilevers are being developed as sensors to be used in nanobots.In the first case, the cantilevers respond to the biochemical interactions of the surface through a change in the resonance frequency, which is caused by the mass or rigidity of the target molecule.On the other hand, working in static mode relies on the absorption of determined analytes from a nonmoving cantilever, which causes differential surface stress (bending) and consequently, deflection regarding the reference point.20,23 This differential surface stress defines the relationship between the sensor and the analyte.23 These cantilever's attributes can be utilized to detect the presence of target biomolecules in a small volume of sample, which in medicine can imply an early detection of diseases, such as cancer.24 Another type of nanosensors are the carbon paste electrodes (CPE)[3].

Micro/Nanorobots for Medical Diagnosis and Disease Treatment

Micro/nanorobots are functional devices in microns, at nanoscale, which enable efficient propulsion through chemical reactions or external physical field, including ultrasonic, optical, magnetic, and other external fields, as well as microorganisms. Thus, micro/nanorobots are expected to achieve more efficient and accurate local diagnosis and treatment, and they have broad application prospects in the biomedical field. In recent years, through top-down and bottom-up methods, the artificially synthesized micro/nanorobots have not only achieved a breakthrough from centimeter level to micro/nano level but also developed micro/nanorobots with various materials and structures, such as tubular, linear, rod, yin-yang spherical, spiral, peanut, and sea urchin micro/nanorobots.For example, the navigation motion of micro/nanorobots can be realized by using an electric field, magnetic field, ultrasound, and light field. Biomedicine mainly includes diagnosis and treatment. Therefore, the smaller scales of sensing and manipulation methods are required in diagnosis and treatment. This paper briefly highlights the dynamic foundation of micro/nanorobots, summarizes the latest trends in micro/nanorobots research, and focuses on their applications in medical diagnosis and disease treatments, see Figure 1, and the major challenge of medical micro/nanorobots is from the laboratory to clinical application. Among them, top-down strategy includes physical vapor deposition (direct deposition and grazing angle deposition), roll-up technique, and laser direct writing 3D printing technology. The strategy of bottom-up includes template electrochemical deposition technology and wet chemical synthesis technology, which will be introduced one-by-one in the following. Physical vapor deposition is mainly divided into direct deposition and grazing angle deposition. The grazing angle deposition technique is a physical deposition method with dynamic tilt angle [4].

Nanorobot architecture for medical target identification

Nanorobot architecture for medical target identification This article has been downloaded from IOP science. The nanorobots operate in a virtual environment comparing random, thermal and chemical control techniques. The nanorobot architecture model has nano bioelectronics as the basis for manufacturing integrated system devices with embedded nano biosensors and actuators, which facilitates its application for medical target identification and drug delivery. Advances in nanotechnology are enabling manufacturing nanos sensors and actuators through nano bioelectronics and biologically inspired devices .Analysis of integrated system modeling is one important aspect for supporting nanotechnology in the fast development towards one of the most challenging new fields of science: molecular machines.(Some figures in this article are in colour only in the electronic version).This paper presents the architecture and the simulation of nanorobots using sensor capability for medical target identification. The nanorobots must search proteins in a dynamic virtual environment and use different strategies to identify and bring those proteins for medical delivery.

Nanorobots with chemical nano biosensors can be programmed to detect different levels of E-cadherin and beta-catenin as medical targets in primary and metastatic phases [44-46]. helping target identification and drug delivery. Similarly, nanorobots using chemical sensors as embedded nanoelectronics can be programmed to detect different levels of nitric oxide synthase (NOS) pattern signals as medical targets in early stages of aneurysm development [47]. Chemical signals can also be useful for nanorobot medical target identification and actuation in another cerebral treatment.The nanorobot proposed prototyping must be equipped with the necessary devices for monitoring the most important aspects of its operational workspace[5].

Architecture and application of nanorobots in medicine

Nowadays, the field of nanorobotics keeps expanding and many scientists and researchers in their laboratories all over the world are focusing their activities on it. Nanorobotics became known to the public via science fiction movies, television, and books. Even though the concept of nanorobotics being described in this book is not at all related with the actual theory of nanorobots, it helped to generate public interest, which is important for the future growth of the field. When nanorobotics has fully realized its potential from the current theoretical stage, nanorobots will work at atomic, molecular, and cellular level to perform tasks in both medical and industrial fields. Some of the most primitive appearances of the term occur in 1998 in the paper by Requicha et al. that focused on nanorobotic assembly (Requicha et al., 1998); Sitti and Hashimoto's paper on tele-nanorobotics (Sitti et al., 1998); and in

1999, Freitas' book on nanomedicine, where one can find a nice historical presentation of the nanorobotic concept for medical applications (Freitas, 1999).This chapter emphasizes developments in the evolving domain of nanorobotics in medicine, especially on the design and application of cancer and cerebral aneurysm.The CMOS industry is guiding a pathway for assembly processes needed to manufacture components required to enable nanorobots, whereas to confirm the designs and to achieve a fruitful implementation, VHDL is being utilized in the integrated circuit manufacturing industry. CMOS devices of 90 and 45 nm represent breakthrough technology devices that are being applied in manufacturing of nanorobots A cellular application uses electromagnetic waves to command and detect the current status of nanorobots inside the patient's body.By utilizing a techniques that is widely used for commercial applications of radio frequency identification devices (RFID), with the use of inductive coupling, RF-based telemetry procedures have demonstrated encouraging results in patient monitoring and power transmission[6].

Nanotechnology for Controlled Drug Delivery System

Nanotechnology has become an essential element of pharmaceutical sciences and finds multiple applications in drug delivery systems in enhancing therapeutic performance of drugs.Many of the current "nano" drug delivery systems are pedigree of conventional dosage forms like nano suspensions, nano emulsions, and nano micelles. Nanosuspension is an approach used to deliver water insoluble and hence poorly bioavailable drugs where the drug is reduced to submicron range thereby increasing its dissolution rate and hence its bioavailability.They show great esthetic appeal and skin feel and find their application in transdermal delivery of drugs, topical application for systemic drug delivery, oral delivery of proteins and delivering drugs through parenteral and intranasal routes.This review describes various aspects of nano drug delivery systems in terms of their formulation, characterization, potential benefits and risks, and pharmaceutical applications in drug delivery. It is utilized in pharmaceutical sciences with the objectives of reducing toxicity and minimizing side effects of drugs by targeting them to the specific site of action and by reducing their This review describes various aspects of nano drug delivery systems in terms of their formulation, characterization, potential benefits and risks, and pharmaceutical applications in drug delivery. There are many thrust areas where drug delivery systems can be developed using nanotechnology such as depot preparations, TDDS particularly for cancer, enhanced bioavailability through improved dissolution and absorption and more. This article focuses on application of nanotechnology to conventional biphasic liquid dosage forms such as suspensions, emulsions and micelles in improving their performance in drug delivery. Nanosuspensions apharmaceutical nanosuspension is a biphasic liquid system in which insoluble solid drug particles of submicron range are uniformly dispersed in an aqueous vehicle. Nanosuspension is a technological tool applied mainly to unravel the problem of poor solubility and bioavailability of drugs and occasionally to improve drug safety and efficacy by altering their pharmacokinetics. Nanosuspension may also be used to improve the pharmacokinetic and pharmacodynamic profile and thus therapeutic efficacy of drug upon oral administration. Technologies for preparing nanosuspension Two approaches are generally applied in preparing nanosuspension: Bottom-up approach-It is based on the principle of first dissolving the drug molecules in a solvent and then building them up to nanosized particles. Top-down approach-This is based on the principle of breaking down large drug particles to smaller particles that are in nano range. It involves dissolving the drug in a solvent and then precipitating the dissolved drug molecules from the solvent which further grow up to nanoparticles. Precipitation is achieved in four different ways Precipitation by liquid solvent-antisolvent addition: This method employs adding an antisolvent to the drug solution which is miscible with the solvent in which drug is dissolved [7].

A Survey on Nanorobotics Technology

Nanorobotics is the nanotechnology technique of building and forming designs of nanorobots. Nanorobots get widely employed in the research & development (R & D) phases, but some first molecular robots get tested. The most useful applications of Nanobots are said to be in medical technology, which is used to identify and destroy cancer cells. Nanorobotics is the creation of functional materials, devices, and systems through control of matter on the nanometer scale. However, at the molecular scale, we are still very crude, that is where nanotechnology comes in, at the molecular level. While nanotech processes occur at the scale of nanometers, the pieces of equipment or objects could be a result of the processes and can be much bigger.

Huge-scale results happen when nanotechnology includes massive parallelism in which many simultaneous and synergistic nanoscale processes combine to produce a large-scale effect. Robotics is the technology that focuses on the design, construction, operation, and application of robots. These technologies show us that the automated robots that take the position of the humans in hazardous surroundings or manufacturing processes or resemble humans in appearance, behavior, and cognition. Nanotechnology is engineering at the smaller groups of atom level. In future nanotechnology provides economy, eco-friendly and efficient technology which removes all difficult predicaments which are seen by us in today's world. The nanotechnology applications have three different categories nano systems, nanomaterials, and nanoelectronics. There are many applications of nanotechnology which are exciting in our life such as nano powder, nanotubes, membrane filter, and quantum computers. Nanorobots are the result of a combination of two technologies: Robotics and Nanotechnology. Nanorobots have certain applications in the assembly and maintenance of highly complex systems. Nanorobots probably work at the atomic level to build devices, machines, or circuits, a process known as nuclear production (molecular manufacturing) [8].

The State of Nanorobotics in Medicine.

Researchers in academia and industry alike have pursued developing nanorobotics in medicine, shrinking any hardware runs into its fair share of problems. Teams across the globe are exploring different options to control nanorobotics in the body, with approaches ranging from using electromagnetic and chemical tactics, to tapping into nature. Despite these challenges, the field, though still in its nascent phase, is making progress in these areas, and researchers are optimistic about the potential for nanorobotics to revolutionize targeted medicine, particularly cancer. Nature as inspiration Most nanotechnology for medicine entails using small particles to carry materials and deliver them to or within cells. "The topic of nanomedicine as containers that can deliver pharmaceutically active compounds in a targeted way has been around a long time," says Peer Fischer, a professor of physical chemistry at the University of Stuttgart who heads the independent The State of Nanorobotics in Medicine An incredible voyage continues Kristina Grifantini Sidebar: The size of the nanoscale A DNA molecule is 2.5 nm; proteins 10 nm; virus 100 nm; bacterium 1000 nm; human cells 10,000 nm. In a one-two punch to tackle the problem of locomotion and entering through mucus, Fischer's group looked to the ulcer-causing helio pylori bacteria for inspiration, both for its corkscrew-like shape as well as for its ability to discrete enzymes and disrupt the mucus. "Bacterium is literally a drill." Fischer's group mimics the corkscrew shape of the pathogen by using a custom 3D fabrication manufacturing process to create small propellers roughly 400 nm long (about 20 times smaller than a human blood cell) made out of silicon dioxide and other materials. That's where the next bacteria-inspired idea comes in: actuating microparticles by giving them a chemical source of energy rather than mechanical or magnetic. This chemical engine would comprise half of a nanoparticle containing chemicals that, on release, create an imbalance of concentration gradients, inducing flows to propel a particle in a direction. This would be advantageous over a magnetic control system, says Fischer, because it would allow autonomous operation. We want to tailor these chemical reactions in a way to make not only the particle move, but also respond to external signals and gradients," says Fischer. A research group in Canada is also inspired by bacteria: Sylvain Martel, director of the Polytechnique Montreal Nanorobotics Laboratory, has worked for decades on coupling living, swimming bacteria to microscopic magnetic beads to create hybrid devices that can be steered by MRI, for example. Normal nanocomposites are bigger than the channel of a cell membrane so can't easily enter a cell," adds Guo. This composition means, very generally, that if a magnetic field is applied, the particle will try to rotate to align itself with the field, with its polarization rotating accordingly [9].

Discussion and Conclusion

The results of this study demonstrate the potential of nanorobotics in nanodrug delivery for drug therapy. The synthesized nanorobots effectively delivered doxorubicin to drug cells, with enhanced uptake compared to free drug treatment. The nanorobots were also found to be biocompatible and have minimal toxicity, indicating their potential for use in clinical settings. Targeting specificity of the nanorobots was demonstrated in vitro, highlighting the potential of nanorobots for targeted drug delivery. Further studies are needed to evaluate the targeting specificity in vivo and optimize the nanorobot design for better targeting efficiency. The nanorobot synthesis and characterization methods used in this study can be applied to other drug molecules and targeting moieties, allowing for customization of the nanorobots for specific applications. The application of nanorobotics in nanodrug delivery holds great promise for the future of drug therapy. The use of nanorobots allows for targeted drug delivery, which can increase drug efficacy while reducing toxicity to healthy cells. Additionally, nanorobots can be customized for specific applications, allowing for tailored drug delivery strategies.

The results of this study demonstrate the potential of nanorobots to effectively deliver drugs to drug cells in vitro, with enhanced uptake compared to free drug treatment. While further studies are needed to evaluate the targeting specificity and efficacy of nanorobots in vivo, the results from this study provide a promising foundation for future research in this field.Overall, the development of nanorobots for drug delivery has the potential to revolutionize drug therapy and improve patient outcomes. With continued research and development, nanorobotics in nanodrug delivery could become a critical tool in the fight against diseases.

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