International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 04, April 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

DNA NANOBOTS FOR ACTIVE DRUG DELIVERY

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ABSTRACT

Nanobots which are also called as nanoids, nanorobots, nanites or nanomites are developed based on the molecular nanotechnology (MNT), with the aim to revolutionise the medical field with robotics at nanoscale to reduce risk factors and to perform its specific task without any side effects. Long term chronic diseases can be cured within few days. It can be used for both diagnostic as well as for therapeutic purposes.

Nanobots, the tiny machines which remain as a theoretical concept might be implemented in the near future. Power supply, navigation facility, communication, locomotion, sensors are incorporated inside the tiny device. Introducing nanobots to the medical field reduces the present cost of medical treatment. This paper focus on the development of DNA nanobots using DNA material which is bio compactible and offers no side effect to our body. Construction, targeting, locomotion, targeted drug delivery has been described.

Keywords: Nanobots, Aptamers, DNA key, DNA walking device, Payload, DNA origami

I. INTRODUCTION

Medical Nanobots can be defined as the robots operating at nano scale, which measures 1-100 nm in length and has a diameter of 0.5-3 micrometre. Since, the nanobots are smaller than the blood cells, they can move inside the blood capillary without any blockage. Nanobots are mainly designed to perform certain specific tasks. It mainly aims at targeted drug delivery, to destroy cancerous cells, remove complicated blood clots, treat genetic disorders etc.

For the designing of nanobots, the major components used are sensors for sensing, power supply for locomotion, navigation, better communication between the physician and nanobot, computation. Also software like NCD (nanorobot control design) can be implemented for the transfer of numerical and physical information to the robot based on its task. Implementing design techniques like 'swarm intelligence', helps the nanobot to manipulate complex systems. Nowadays, followed by the advanced technology, microchip based drug delivery system can be incorporated with the nanobots.Nanobot design is based on virtual reality.

Nanobots can be injected directly into our veins or arteries or to our body cavity or with the help of catheters inserted into our arteries. It can be employed for both diagnoses as well as used as therapeutic agents. Mainly it is used for targeted drug delivery without causing any side effects to the patient's body. Nanobots in the bloodstreams can be tracked with the help of ultrasonic waves, by injecting contrast dye or with the help of MRI, magnetic fields.

Medical Nanobots perform a lot of functions in the medical field. Nanobots can be used for both cancer diagnoses as well as for treatment. It can be employed for targeted drug delivery into the cancer cell. Drugs are

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

delivered into the specific cancer cells without causing any damage to the healthy cells, with fewer side effects as compared to chemotherapy and radiation therapy. It can also be used to treat arteriosclerosis. Arteriosclerosis refers to the condition where blockage fluids along the walls of arteries. Nanobots remove the blockage by physically cutting away from without causing any damage to the arterial wall. It is also used for removing blood clots. Nanobot's removes blood clots formed even in the complicated blood-brain barriers. It is used to remove kidney stones. Formation of kidney stones cause difficulty in urine passing and is extremely painful. Nanobots using laser technique to break kidney stone without any pain and is more precise than other technique. Nanobots are also used in dentistry. Nanobots can be used to maintain oral hygiene. It is used for cavity preparation and its restoration. Taking a mouthful wash of Nanobots helps in killing pathogenic bacteria's, cleans the food remains attached between the teeth where toothbrush bristles cannot reach. It is used for gene therapy. Nanobots can be used as internal medicine to treat genetic diseases. Irregularities in DNA structures and protein structures can be analyzed and corrected chromosome replacement therapy is better. Nanobots can be employed to perform surgery by introducing them into the body through catheters or body cavity to perform surgeries.

II. DESIGN OF NANOROBOTS

The Nanobots are divided into two structures: an exterior part, which interacts with the body fluids and an interior part, which is an air tight vacuum that has no contact with the body fluids unless it opens for sampling the surface chemicals. The surfaces of nanobots are made up of carbon atoms probably in the form of diamond and its surface is smooth enough and biologically inert that pre vents the attack of blood leucocyte.

Fins and propellers: Nanobots consist of fins and propellers that helps in its locomotion. Once the nanobots injected into the bloodstream, the fins are activated by providing external magnetic field, in which the fins vibrate, helps in movement. Propellers result in unidirectional as well as bidirectional motion of the nanobots. Propellers guide the nanobots for direction change.

Molecular sorting rotors: These help the nanobots to change its direction based on its requirement. Also, it selectively binds or releases molecules from the or to the blood and transports these molecules against a concentration gradient.

Nano-bearings and Nanogears: Nano-bearings and Nanogears are obtained by the precise arrangement of atoms on the surface of nanobots that enables maintain the position of nanobots in bloodstream. Nanobearings consist of 206 atoms arranged together and nanogears consist of 3557 atoms of primary and elementary elements held together by vanderwaals force. Nanobearings consist of small rotating shaft inside a ring slave. Ring gear helps to position the Nanobots in bloodstream.

Nanosensors: Nanosensors or nano computer enables the continuous monitoring of patient system and are more reliable. For navigation, nanobot make use of long term and short term sensors, which helps in distinguishing healthy and unhealthy cells. Chemotactic sensors which are arranged around the surface of nanobots come in contact with the various chemical components of the blood, in which it can distinguish between them with its specific binding sites. Many internal sensors like chemical spectroscopic, TV camera can be employed to locate target sites. Acoustic sensors can be used to communicate between the physician and nanobot, through which the physicians provide correct information to guide the nanobot.

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Power supply: For any electronic device to work, it requires power supply. Since nanobots are very small, batteries or solar cell cannot be used because of their large size. In order to overcome this, both external as well internal methods of providing power to the nanobots need to be considered.

Nanobots can derive energy directly by utilising blood glucose and oxygen. The molecular sorting rotors bind the glucose and oxygen molecules from the bloodstreams and derive them to the fuel tank, where by mechanically or hydraulically energy is utilised for rotor movements. Nanobot can also be powered by mounting electrodes above I and energy is derived between the electrodes and the blood acting as electrolytes. Thin film of radioactive material can be used as a power source, where it utilises the decaying atoms for energy consumption. External way of powering involves broadcast method using acoustic signalling.

III. WORKING PRINCIPLE

DNA NANOBOTS FOR ACTIVE DRUG DELIVERY

DNA nanobots are employed to perform the targeted drug delivery and also it acts as a biosensor. It selectively delivers payload by identifying the unhealthy cells from the healthier cells. DNA nanobots are made up of active DNA nanostructures and are better option for the construction of nano machines as they are biocompatible and have no side effect on human body. DNA molecules also has the ability to self-assemble themselves into 2D - 3D structures by Watson-crick force of attraction ,by vaanderwaals force of attraction and other synthetic joints between the bases of DNA molecules. The concept of DNA nanobot designing consist of a box shaped structure with lids that are latched by placing drug to be delivered inside the box. When these nanobots come in contact with the target site, the lid flap opens resulting in active drug delivery. The DNA nanobots are designed in such a way that, it performs its task by undergoing the series of state changes. The state change comprise of hybridising of a single base or entire strand.

For the construction of DNA Nanobots, a long stretch of single stranded DNA is folded into a hexagonal barrel with two opposite ends set open. The process of folding DNA to a desirable shape is known as DNA origami. It allows the precise arrangement of molecules. The desired hexagonal shape is obtained with the help of small fragments of DNA strands called staples. These staples provide a 2D-3D structure for DNA vessels by appropriately combining with the bases of the long DNA strand. The genetic sequence of the staple is determined with the help of computer software. So that the entire structure can be obtained using the complementary pair. The payload that contains the drug to be delivered is placed inside the hexagonal barrel. A fluorescence labelled antibody is used as payload. So that the pathway can be correctly tracked without error. The two ends of the barrel are latched using an aptamer one end to the DNA hinges.

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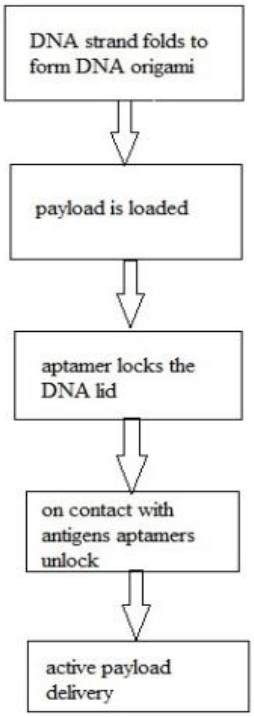
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346



Aptamers are artificial nucleic acid that acts as a latch which locks the vessel and unlocks only when it comes in contact with the DNA key. Two different aptamers are used to lock the vessel. Each aptamer is sensitive to bind with two different antigens. These aptamers set open only when they are in contact with the DNA keys.DNA keys are antigens present on the surface of the cancerous cells, which unlocks the aptamers and result in release of drug at the target sites. When the drug is release it binds with the surface antigens of the cancerous cells. Thus it blocks the uncontrollable cell division resulting in cancer. An aptamer can act as a sensor by correctly identifying the antigens; it performs logical computation by selectively binding with the antigen resulting in a state change. DNA nanobot are used for drug delivery in cancer cells. The payloads are attached with a fluorescence combined antibody, which has specific affinity to the antigens. It is used for the treatment of leukaemia.

Movement of DNA nanobots: The motion of DNA nanobots is carried out by external environmental changes. To initiate a translational unidirectional motion of the nanobots, a DNA walking device is used. The device consists of a track and walker. The track provides an anchorage site in a linear fashion. The walkersteps on the anchorage site resulting in its motion. The walker is a flexible physical entity which acts as a nano particle carrier apart from acting as an information carrier. These walkers undergo ligation and cleavage resulting in motion of nanobots. The complementary sticky ends of the walker and neighbouring dangler undergo hybridization and they associate with each other resulting in ligation. Then for further movement the ligated site should undergo cleavage using the cutting enzyme restriction endonucleases. It recognises the recognition site and cuts the ligated site resulting in the separation of the sticky ends. The free walker leg now target for next anchorage site of complementary dangler. ThusDNA nanobots travel along a single stranded DNA. Three enzymatic DNA legs bind and cut the strand attached to origami. It undergoes ligation and cleavage enabling movement. DNA legs of the origami binds with the base of DNA strand without utilising energy. But it undergoes cleavage by utilising energy resulting in origami movement to destination.

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

IV. CONCLUSION

Nanobots, the nanoscale device, its type and applications are discussed in this paper. It is a combination of molecular nanotechnology, nanoelectronics, robotics and biomedical engineering. Even it remains in a progressive stage; it shows a way to solve many problems in the medical field including cancer treatment without chemotherapy, treating genetic disorders, can perform major operations in the blood-brain barriers. Nanobots are highly durable, can operate at a faster rate and are precise and accurate in performing its task. Novel chip terminology on integrating with Nanobots increase the scope to deal with complex systems. By 2020, scientist aims at introducing Nanobots to the market at an affordable price, and to conquer the medical field within the arms of Nanobots.

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ISSN (P) 2319 - 8346

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