**An insight into Nano-sensor and It’s Application in disease Detection**

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**Abstract:**

There has been a need of a continued development in the selective cost-effective hand-held biosensors with a rapid response and detection compared to already existing lab assay method for detection. The recent advancements in the field of nanotechnology have prompted the development of nanoscale instruments the exhibit different powerful features which is important for various application. Nano sensors are nanoscale devise that measures physical quantities and covert these signals for detection and analysis. Nano sensors have potential in the area of diagnostic medicine for it can enable early identification of disease without relying on any visible or clinical symptoms. In this book chapter we have discussed the use and principle of nano-sensor in in smart health car, diagnosis of various diseases. In this chapter nano-toxicology of nano material was also discussed with reference to various organ. This chapter summarizes of about nano-senros and current challnegrs in maintaining nano-sensors with it’s future application along with its limitations

**Keywords:** nano-sensor,nano material,biomedical diagnosis, sensor

**INTRODUCTION:**

In the areas of scientific research, nanotechnology has attracted much more attention in the recent years. In addition to producing unique material, nanotechnology has the potential to create new equipment at molecular level to exploit and control disease identification and control in nanoscale 1. Therefore, the use of Nano-sized objects such as a variety of natural nanoparticles as drug carriers and/or tumour detection agent can be considered as a major achievement.2 Nano-sensors is the device which can detect any type of stimuli and later convert into signals which can be measured is known as sensor. Nano-sensors are the device with a dimension of 100nm.3 These are the tiny devices which can be transformed chemical, physical or biological substance into detectable signals. This device is cost effective and provides different efficient methods for detecting and measuring chemical and physical characteristics change in molecular level4. There are a wide variety of applications for nano-sensors, and they are increasingly becoming the preferred technology. There are various types of nano-sensors are available such as nano-chemical sensors, electrochemical nano-sensors, and biosensor etc. nano sensors have multiple application in identification of disease progression, drug delivery at deeper biological level and etc.5 it provides better understanding of person’ s health status in a non-invasive way detecting clinical biomarkers in several biofluids without any complex manipulation. One of the most promising approaches to comprehend the biology and management of diseases is the development of nano-sensors for disease detection.7 Though it is a relative new technology, sometimes it has limitation in biological system. It may impact the cell metabolism and homeostasis, sometimes it causes difficulty in separating sensor-induced artifacts from fundamental biological phenomenon. 8. This chapter summarizes the different type of nano-sensor, it’s application in biological system, current challenges and future perspectives.

**Characterization of Nano-sensors**

Sensors are the tools that can recognize and sense particular signals. The signals may be optical, electronic, electrical, mechanical, biological, chemical or physical etc. Nano-sensor, a relatively recent invention, are essential for the development of nanotechnology. These are the sensing devices that measures physical quantities and turn it into signals which can be easily detected and evaluated .They are incredibly tiny devices having a dimension of less than or equal to 100 nm that transform chemical, physical or biological substances into detectable signal9 .The device offers quick and affordable ways to measure and detect minute physical and chemical changes. The device employed in a wide range of sensors application, includes disease detection, treatment and therapeutic drug monitoring 10Nano-sensors can be fabricated using top-down, and bottom-up techniques [14]. The top-down approach, which employs a physical strategy , reduces the dimension of the initial size by using special size reduction technique. Bottom-up or chemical methods are utilized to create nanosemsors at the atomic or molecular level.11 Nanosensors are c.ategorized into different categories 3 different types which is summarize in the figure 1 Fluorescence is the newly approached method in nano-sensor, for it’s ease of use and greater sensitivity.12 chemical nano sensor generally deployed to detect pollutant, drug development and assay of different poisoning like organophosphorus.13 in case of physical nano sensor, it monitor the physical properties like flow, force, temperature and then converting them into signals which can be easily detected and evaluated.14.

Schematic diagram elucidating of Various Nano sensors is depicted in Figure 1.



 **Figure 1: Representative diagram of various types of Nanosensors**

**CONSIDERABLE POTENTIAL OF NANO-SENSOR IN MEDICINE:**

There is increasing demand in health sectors and seen technical development. Nanosenor reduces the average detection time, diagnosis and cost-effective goods 15 In the recent development of nano-sensors for disease detection is one of the promising approaches to comprehend the biology and management of diseases. This is utilized to determine the “molecular signature” of a physiological disease condition at a specific time and is therefore crucial for accurate disease development and early detection of disease. Additionally, it provides details on the mechanism that lead to the development of disease and eventually offers effective strategies for diagnosis and therapy.

1. **Glucose Monitoring in Type I diabetes mellitus:**

The in vivo glucose sensors are primary developed in order to detect hypoglycaemia in people with insulin dependent (Type 1) diabetes. Fluorescent nanoscale and microscale devices can be used to detect glucose in blood. The use of micro/nanoparticles in the skin may allow transdermal monitoring of glucose level in the interstitial fluid. To achieve sensitive responses, coating colloids and microcapsules with nanotechnology allows precision control of optical, catalytic and mechanical property. By using non-invasive glucose sensors, implant biocompatibility problems will be overcome and patient acceptance will be maximized20.

1. **Asthma Detection :**

A handheld device that measures the quantity of nitric oxide in the patient’s breath can be used to employ a nano-biosensor to identify asthma attacks up to three before they happen. Regular testing, similar to what a diabetic patient would do to check their blood sugar level, could save life.21 They could be altered if they know about their breath’s nitric oxide level is high or rising. In this case, it would indicate the patient’s risk of asthma attacks22.

1. **Detection of bacteria:**

23. There are Limitation to most conventional diagnostic methods, including a lack of ultra-sensitivity and delay in results 24. There have already been several nanotechnology -based methods described , including ferrofluid magnetic nanoparticles and ceramic nanospheres25. By using a bio conjugated nanoparticles bioassay for in situ pathogen quantification, a single bacterium can be detect within 20 minutes. The nanoparticle can be easily used in a biorecognition of molecule such as an antibody due to their high fluorescence27. One limitation of quantum dot technology is that it gives qualitative information but not provide quantitative information. The nanoparticle-based colorimetric assay, in comparison to a previously reported absorbance-based method, increases detection sensitivity by over four orders of magnitude28.

1. **Cancer Diagnosis:**

Over the past ten years, there has been a lot focus given to the creation of nanotechnology-based test kits for diagnosis of cancer. In comparison to the cancer diagnostics that are currently accessible in the clinic, a number of Nanoparticle based testes showed advantages in terms of selectivity and sensitivity, or they offered whole new capabilities that were not achievable with conventional techniques. These advancements will improve cancer patients chances of survival by enabling early detection . These advancement may also be used to monitor the progression of disease and how treatment affects it, which could help physician to build more efficient cancer treatment regimens29. There is a significant progress in ultrasensitive analysis and cell imaging due to the electroluminescence nano-sensing systems. Electroluminescence nano-sensor can open up new avenues for cancer diagnostics because of their special advantages of high selectivity, ultra-sensitivity and remarkable reproducibility. The invention of Electroluminescence nano-sensors has made it possible to perform high -throughput analysis, visual detection, and spatially resolved Electroluminescence imaging of individual cells. The innovations of Electroluminescence nano-sensor consist of electrochemical excitation, light radiation and luminescence signal amplification30.

**Cardiovascular Disease:**

The prompt and accurate identification of pertinent biomarkers and function parameters can provide clear indication of the physiological or pathological processes underlying cardiovascular disease. Cardiovascular diseases can be quickly diagnosed using nano-sensors that combine the benefits of nanomaterials and sensing platforms, mostly for early detection31. Different from conventional molecular therapeutics, nanomedicine enables the design of multi-component, multi-tasking, multi-modular agents that can simultaneously and precisely detect and treat disease. For example, we can envision smart nano-sensors integrated in existing implants such as defibrillators, stents or pacemakers that may trigger warnings, or perhaps acute release of drug, if required. Another nanomedicine solution for CVDs could be projected for vulnerable plaques; ‘click chemistry’ or highly controlled cross-linking strategies targeting and ‘securing’ the plaque before subsequent AMI without danger of occluding the vessel could be utilized.32

1. **Therapeutic drug monitoring**

Among all biosensors, nano-sensors have proven to be the most effective at detecting acute organ rejection and drug monitoring33. To monitor stem cell differentiation prior to transplantation in therapeutic application, nano-sensors are being used34. Patient with Parkinson’s disease can benefit from this technique since it enables the monitoring of cellular surface proteins and neuro-transmitters and verify the differentiation of stem cells into dopamine producing neural cells35. The few instances of biosensing applications in regenerative medicine could make strategies of keeping track of and managing cellular biological structures. As the biological components of a nano-sensor, the reports on in vivo and continuous implanted sensing are rare. (i.e., the bioreceptor that comprises antibodies, enzymes or other agents) may limit its lifetime even if implanted. Additionally , irreversible binding and non-selectivity are limitations of in vivo sensing 37.

1. **neurotransmitters detection:**

The physiological state and behavioural patterns of the brain and body are maintained by neurotransmitters.

The ability to decipher complicated brain pathology is enhanced by studies on transmitting mechanisms and changes in the concentration of specific neurotransmitters. This knowledge advances our ability to create novel therapeutic and diagnostic interventions. When compared to other methods, using nano-biosensors to examine neurotransmission and dynamic changes in neurons produces data that are generally more, rapid , accurate and significant that those produced by other conventional methods38. The incorporation of organic and inorganic nanostructures, such as carbon nanotubes , metal oxide nanoparticles and polymers are frequently used to fabricate sensing films with significant biocompatibility and better redox properties , and other nano-sensing frameworks are also receiving attention. New nanomaterials- based sensing is being used to speed up the detection of neurotransmitters, which is facilitating fluorescent or colorimetric based processes39.

**PITFALL OF NANO-SENSORS**

Compared to conventional sensors, nano-sensors have a number of advantages, but they also have a number of disadvantages40 In some circumstances, the development and implementation process as a whole could be quite expensive The process of developing nano-sensors takes time as well. Nanomaterials may be hazardous to human tissues and cell cultures depending on their composition and concentration 41(

**FUTURE PERSPECTIVE:**

The market for biosensor is expanding as a result of their extensive application in healthcare and medicine. Additionally, biosensors have advanced in a number of fields, including diagnosis, patient health monitoring, illness detection, and human health management, which will open the door for rapid advancement42. In a wide range of applications, nano-sensors are quickly replacing other technologies. They provide effective and affordable ways to measure several parameters in hard -to-reach biological and industrial systems functioning at the nanoscale, including chemical and physical properties10. Nano-sensor technologies have a wide range of applications in the fields of medicine, agriculture, the environment, society and the military. Comparing standard chemical and biological techniques to nano-sensors reveals considerable gains in selectivity, speed, and sensitivity. They can be used to determine the presence of bacteria, pollutants, contaminants and freshness of food and disease detection & progression43.

**CONCLUSION**

In the expansive realm of optical, chemical and biosensing, nano-sensors are an especially fascinating component of research and development. Nano-sensors are defined as any surgical, biological and chemical sites used to transmit information about nanoparticles into the macroscopic environment. Due to their small size and distinctive optical, magnetic, catalytic and mechanical properties, nano-sensors have made significant advancement in development and use. To transfer nanoparticle information to the macroscopical environment, any functional, biological, or chemical points are used. Numerous industries, such as healthcare, environmental monitoring, and industrial applications, have benefited from the breakthroughs achieved by nano-sensors. They still have a number of issues, nevertheless, which prevent their widespread use. Nano-sensor’s sensitivity and detection range are essential for detecting analytes at low concentrations. The selection of materials can be optimized, new transduction processes can be created, and sophisticated signal amplification methods can be investigated. The biocompatibility and safety of nano-sensors are vital in biomedical applications. To solve these issue, it is crucial to conduct thorough toxicity studies and choose materials that are biocompatible. In particular, nano-sensors should be reliable and resilient in severe conditions and under prolonged operations.

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