AN INSIGHT INTO NANO-SENSOR AND IT'S APPLICATION IN DISEASE DETECTION

Abstract

To enhance current lab assay methods for detection, it has been necessary to build selective, affordable, hand-held biosensors with quick reactions, and detection. The recent advancements in nanotechnology have prompted the development of nanoscale instruments the exhibit different powerful features which is important for various application. Nano sensors are the nanoscale devise which measures the 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 care, 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-sensor and current challengers in maintaining nano-sensors with its future application along with its limitations

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

Authors

Ms. Sucharita Babu
Assistant Professor
School of Pharmacy and Life Sciences
Centurion University of Technology and Management
Bhubaneswar, Odisha, India.

Dr. Bikash Ranjan Jena
Associate Professor
School of Pharmacy and Life Sciences
Centurion University of Technology and Management
Bhubaneswar, Odisha, India.

Dr. Biswakanth Kar
Assistant Professor
School of Pharmaceutical Sciences
Siksha 'O' Anusandhan
(Deemed to be University)
School of Pharmaceutical Sciences SOA University
Bhubaneswar, Odisha, India.

Dr. Santosh Kumar Ranajit
Associate Professor
School of Pharmacy
Centurion University of Technology and Management
Bolangir, Odisha, India.

Mr. Anup Kumar Dash
Assistant Professor
Tagore institute of pharmaceutical science & Research
Sakri bilaspumr Chhatisgarh, India.

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I. INTRODUCTION

In the areas of scientific research, nanotechnology has drew much more attention in the past 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, using nano-sized items as drug transporters and/or tumour detection agents, such as a range of natural nanoparticles, can be a significantly accomplishment 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 100nm3. These are the tiny devices which can be transformed biological, physical and chemical substance into detectable a signal. The device is cost-effective and offers a variety of efficient methods for detecting and measuring changes in chemical and physical characteristics at the 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. It is among 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. It is a device that measures the physical quantities and converting them into a signal that can easily be detected and analysed. 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 10. By using top-down and bottom-up techniques nano-sensors can be fabricated. 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 nano-sensors at the atomic or molecular level11. Nano-sensors are categorized 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 organophosphorus13. 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 detectable and evaluated14.

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

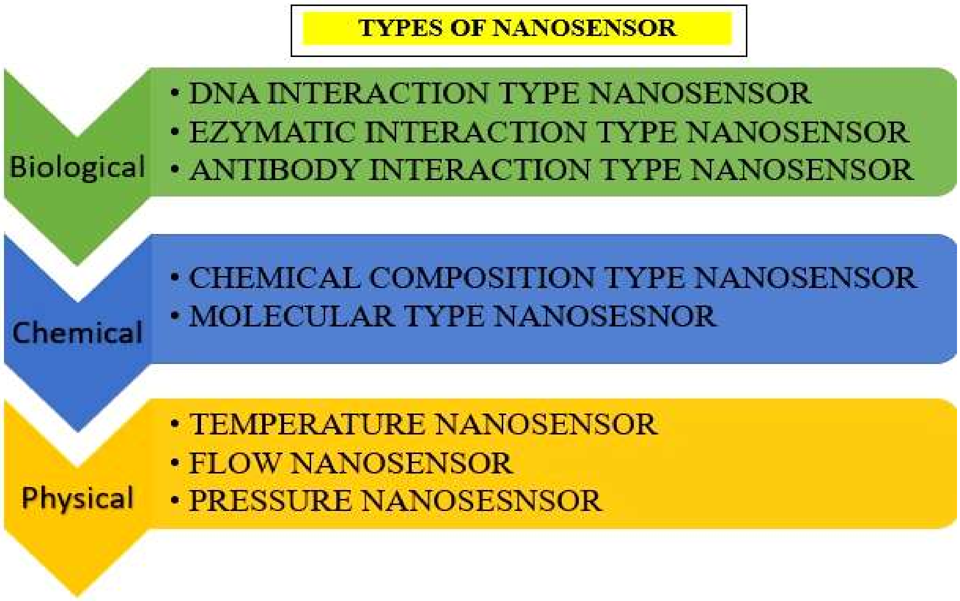

Figure 1: Representative diagram of various types of Nanosensors

II. CONSIDERABLE POTENTIAL OF NANO-SENSOR IN MEDICINE

There is increasing demand in health sectors and seen technical development. Nano-senor 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 greater approaches to comprehend the cell biology and management of diseases. In this way, an individual can determine the "molecular signature" of a given physiological condition at a particular in 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 Type I diabetes mellitus. Fluorescent nanoscale and microscale devices can be used to detect glucose in blood. It is possible to monitor glucose in the interstitial fluid via micro/ nanoparticles embedded in the skin. To achieve sensitive responses, microcapsules and coating colloids 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.

2. **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 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

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know about their breath's nitric oxide level is high or rising. In this case, it would indicate the patient's risk of asthma attacks 22-23.

3. **Detection of Bacteria:** There is limitation to traditional diagnostic methods, including a lack of ultra-sensitivity and delaying in results24.There have already been several nanotechnologies -based methods described, including ceramic nanospheres and ferrofluid magnetic nanoparticles 25. Numerous nanotechnology -based techniques, such as ferrofluid magnetic nanoparticles and ceramic nanospheres, have already been reported. A single bacteria can be found within 20 minutes by using a bio conjugated nanoparticles bioassay for in situ pathogen quantification26. Due to their strong fluorescence, nanoparticles can be utilized to biorecognition molecules like antibodies27. The fact that quantum technology only provides qualitative information, as opposed to quantitative information, is one of its drawbacks. The detection sensitivity of the nanoparticle-based colorimetric assay is over four orders of magnitude higher than that of a previously reported absorbance-based approach. 28.

4. **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 sensitivity and the selectivity 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. This 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 cell imaging and ultrasensitive analysis 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 light radiation, electrochemical excitation and electrochemical excitation, light radiation and luminescence signal amplification30.

5. **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. Nanomedicine, as compared to traditional treatments, permits the development of multi- tasking, multi-component, multi-modular, agents that can precisely and simultaneously cure he diseaseFor instance, we may picture integrated nano-sensors built into current implants like defibrillators, stents, or pacemakers that, when necessary, can trigger alerts or even the acute release of a medicine. Nanomedicine solution for cardiac disorder could be projected for vulnerable plaques; without danger of occluding the vessel could be utilized32.

6. **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 transformation of stem cells into neuronal cells that produce dopamine 35. The few instances the use of biosensing 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 various in vivo and continuous implanted sensing are still rare. (i.e., like the bioreceptor that comprises enzymes, antibiotics etc may limit the lifetime even if implanted. Additionally, irreversible binding and limitation due to the non-selectivity in in vivo sensing 37.

7. **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 neurotransmitter's concentration and it's transmitting mechanisms 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 inorganic and organic nano-structures, such as carbon nanotubes, polymer, metal oxide are frequently used for fabrication of sensing films with significant biocompatibility having better redox properties. 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.

III. 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. Depending on their composition and concentration, nanomaterial may be harmful to human tissues 41.

IV. 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. At a comprehensive application, nano-sensors are quickly replacing other technologies. They provide effective and affordable ways to measure several parameters in order to get industrial and the biological functioning at the nanoscale, including chemical and physical properties10. Nano-sensor technologies have a wide range of applications in the fields of medicine, agriculture, 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.

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V. CONCLUSION

In the expansive realm of optical, biosensing and chemical, nano-sensors are an especially fascinating component of research and development. Nano-sensors are defined as any chemical, physical, biological and surgical sites used to transmit information regarding the nanoparticles into the macroscopic environment. Due to their small size and distinctive optical, catalytic, mechanical and chemical 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 sector, industrial application environmental monitoring etc, 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 this 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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