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Significance of Nanotechnology in Various Nano Biosensors for Detection of Viruses

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Abstract

In present scenario biosensors are the hottest topic for the researchers because in this decade a pandemic expanded over the world. Covid 19 pandemic spreaded like a hazard putting everything on the brink of collapse. The early diagnosis of infection from virus can prevent the large tragedy. Many old methods are available for detecting the viruses but many fatal viruses cannot be diagnosed by this method. Biosensors are made by nano materials which provide best result for detection of viruses because nano materials have large surface to volume ratio. Large specific surface area and high free surface energy have an important role in the surface adsorption of biomolecules.

Keywords : Nano materials , Biosensors.

Introduction

A sensor elucidate as a device which is accomplished to detect the appearance of analyte in a sample and evaluate it. The sensor consists of a detection system called a receptor , a transducer, and a readout system. The acceptor is a biological element that is fixed on the converter in different ways in biosensors [1,2,3,4,5]. This biological organ has a high selectivity for biological interactions and analyte detection (there is a specific interaction between the receptor and its ligand in biological systems) [6,7,8,9]. A high quality biosensor explained by hugely on how the bioreceptor layer (biological component) is present on the transducer. Mainly a close relationship is determined between the biological element and the sensory surface (converter) while maintaining (and even improving) the stability of the biological component [10,11]. Sensors quality are determined with several important features [12,13] such as selectivity of the sensor that indicates how much system is efficient to discriminate the analyte from other materials in the sample [14,15,16,17]. The high quality of biosensors is explained in other words that larger the selectivity, the more effective the sensor which is identifying and measuring the analyte with the least interference in the sample from other materials [18,19,20,21,22]. Sensitivity is the next important feature of biosensors [23]. High sensitivity is observed with minimal changes in analyte concentration, a significant change in the output signal from the sensor. Such sensor has the high resolution [24,25,26,27,28]. Another important feature is repeatability (measurability) the results of measurement that is defined by the term accuracy [5,6]. Accuracy indicates that the measurement results are close to the actual value. Today nano materials have been used on large scale in the fabrication of biosensors [29,30,31,32,33].

The diseases spread by viruses are very fatal. A wide range of hosts such as human, poultry animal insects, plants, even microbes can be griped in diseases. So it is important that viral diseases should be recognized early and controlled at initial stage. There are many methods which are available to detect the viral diseases such as molecular approaches, serological methods, direct virus culture methods. A method of direct detecting viruses is culture technique which determine the amount of virus in a sample or viral titers (i.e. strength of antibody antigen binding). Plaque assay is used to determine the number of infectious particles in sample. The infected cell area

will create a plaque (plaque is an area of infection surrounded by uninfected cell). Focus forming assay is immune staining technique. These assays detect infected host cells and infectious virus particles before a plaque is formed. This can easily detect the advancement of various materials. Such as carbon nanotubes, grapheme, carbon nano particles, nano sized clay and different nano structures polymers etc. The fluorescent focus test is also known as transformation assay. The transform cells after infection can be easily detached from uninfected cells in a monolayer culture plate [34].

Other type technique use for the viral testing is known as serological diagnosis. In this technique we utilize fast antigen assays. This test provides whether a certain antigen is present or not in patient's serum. ELISA is the serological diagnosis process. This is expensive technique. RIA (Radio immune assay) technique used to measure the concentration of antigens through the use of antibodies directed against these antigens. Here radio labeled and unlabelled antigens compete for binding to high affinity antibody. Rapid test kit based on antigen- antibody reaction used in corona virus detecting is used to detect virus. Different polymers are also useful for detecting the virus in future aspect [35]

Biological materials

As all of us know that the range of nanomaterials and nanostructures lies in 1nm to 100nm. So many biological materials are also studied as nanostructures cause of their size. The range of bacteria size is 1μm to 10μm which is called mesoscopic range. While the range of virus size is 10nm to 200nm, this range is upper part of nanoparticles range. There are 20 amino acid each of size 0.6nm makes a building block of proteins which belongs in lower limit of nanoparticles. More than 100amino acids occurs naturally, but only 20 acids are involved in protein synthesis. For the construct a protein more than 100 or either in some cases 1000 amino acids are tied together one after other by the help of strong peptide chemical bond and a long chain of protein form which is called polypeptides, hence this chain corresponds to nanowires. This polypeptides nanowire undergoes twisting and turnings to compact themselves into small volume like a polypeptide nanoparticles having diameter in range of 4-50nm. So the protein is a nanoparticles made of compact polypeptide nanowire (D.N.A.) deoxyribonucleic acid genetic material is also a compacted nanowire. In this structure four nucleotide molecules are bind together in a long double helix nanowire which form the chromosomes. When two nucleotide nanowires are twisting around each other with diameter 2nm and repeat unit each 3.4nm construct a D.N.A. molecule. This double nanowire twisting and turning a systematic form becomes a chromosome with 6μm long and 1.4μm wide. The size of chromosome lies in mesoscopic range.

A new question strikes that which instruments are used for transducing the biochemical events into electrical signals. Electrochemical biosensor is one of the typical devices using as transducer. In this sensor an electrode play as important component which employed as solid support for immobilization of bio molecules and electron movement. Several nanomaterials possess large surface area and cause of synergic effects the loading capacity improve. The features of nano materials provide high performance such as mass transport of reactants for analytical sensitivity. Tiny organism viruses and their related disease can be harmful for humanity. Sometimes in this hazard situation are putting the life on the brink of collapse. So it is most significant step taken to prevent this hazardness by the different diagnostic techniques. There are many traditional methods are used to detecting viruses such as molecular approaches, serological methods, direct virus culture methods and so on., but these methods are not sufficient because some stages are not devoid of drawbacks. Presently new techniques are introduce or developed in medical area which eradicates the demerits of previous procedures. Biosensors have come up with a lot of benefits in terms of detecting viruses and their diseases. Various types of viruses are appeared so various types of biosensors are developed such as affinity based biosensors, optical nano biosensors, nanoisland affinity biosensors, fiber optic nano biosensors, surface Plasmon resonance (SPR) based optical nano biosensors etc. Electro chemical nano biosensors are sensitive to detect virus quickly.

Molecular electronics and nanoelectronics ;

Nano electronics and molecular electronics are broad areas for the change of a new era. It is expected, that single molecule is able to control the electron transport in molecular electronics. The nature of electron transport in molecular electronics explored the vast variety of molecular functions for electronic devices and molecules can now be crafted into a working circuit as shown schematically in Figure 1

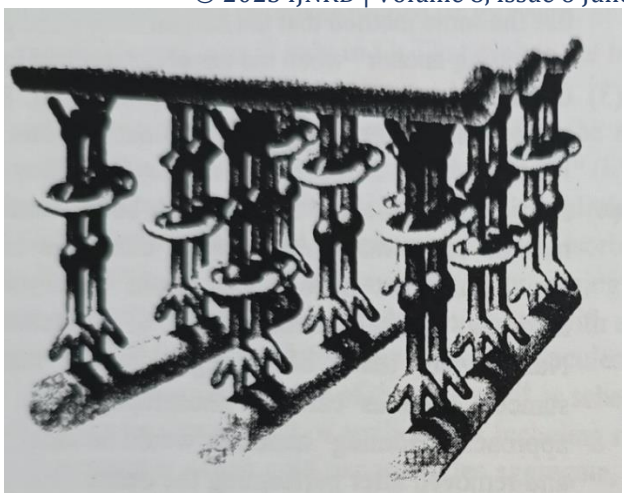

Figure 1- Schematic showing that molecules can now be crafted into working circuit, though constructing real molecular chips remains a big challenge [36].

When molecules are biologically active, bio electronic devices could be developed.[36,37,38]. In molecular electronics a poorly organized and partial monolayers of molecules are situated. Once these surfaces become interfaces, electrostatic rather than electrodynamics are exert by these layers, which control over the resulting devices who are based on electrical monopole and dipole effects of the molecules. So the electronic transport devices including organic molecules can be fabricated without current flow through the molecules. Sensors are good example of molecular electronics, which provide unique molecular properties into electrical signals Sensor made by field effect transistor (FET). Its gate displaced into a liquid electrolyte, and an active layer of molecules for molecular recognition were reported in 1970's[39].

Type of Nano biosensors

The classification of nano biosensors is very diverse area. These are based on the nature of nano materials incorporated in the bio sensing operation, such as nano particles based nano biosensor, Nanotube Based Sensors, Nanowire Based Sensors. Nano particle based biosensors are made by nano materials and increase the signals strength. These are again devided in three categories i.e acoustic wave biosensors, magnetic biosensors and electrochemical biosensors. Acoustic wave biosensors have been developed to amplify the sensing responses so as to improve the overall preciseness of the limits of bio detection. The large mass of bound sol particles of the antibody change in the vibration frequency of the quartz based sensing platform, this change behaves as the detection. Generally the preferred diameter of the sol based antibody particles is between 5 and 100 nm. The gold, platinum, cadmium sulphide, titanium dioxide particles are preferred [40,41]. Magnetic biosensors utilize the specially designed magnetic nano particles and these are mostly based on ferrite materials. These devices are screened the specific antigens from the mixtures by using antibodies bound to magnetic nano particles [42]. Electro chemical biosensors are the sensors which basically work to facilitate or analyze the biochemical reactions with the help of improved electrical means. Since their discovery in 1990's Carbon nanotubes are one of the most popular nano materials known right now in the world for optoelectronic applications. They have attracted extraordinary properties such as electronic conductivity, flexible physical geometric features, and mechanical properties having high mechanical strength and folding abilities. Because of these features in both single wall nanotubes and multi wall nanotubes have been used in designing biosensors for better and better performances [43,44]. Nanowire based biosensors, In one such study, Cui and Lieber group have reported the performance of biosensors based on silicon nanowires doped with boron and used them for the detection of biological and chemical species [45].

CONCLUSION;

The biosensors are applicable in screening of viruses and bacteria as biomedical and diagnostic applications. The existence of human life is impossible without environment so biosensors are useful in environmental applications. The biosensors are also part of miscellaneous applications such as in the industrial operation. Nanotechnology has really proved to be a very significant blessing in the development of biosensors. It has revolutionized the case of biological detection. The transduction mechanisms have been significantly improved with the use of nano materials and nanostructures like those of quantum dots, nanoparticles for enzyme immobilization, and hybrid nanostructures with multiple functionalities. The purpose of using of nano materials in the biosensors is to increase the level required to stabilize biomaterials, sensitivity, catalysis of the process, the possibility of reacting at low potentials and helping the rapid transfer of electron from the active reaction center to the electrode surface (in electrochemical nano sensors). By reducing chemical intermediates of electron transfer to receptor play an important role in the development of third generation biosensors. In the sense of that features nano materials in the biosensors have great importance. Nanoparticles due to their large specific surface area and high free surface energy have an important role in the surface adsorption of biomolecules.

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