CHAPTER: 10

ROLE OF QD-FRET BASED NANOSENSORS IN DETECTION OF VIRUS: A REVIEW

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ABSTRACT

For urgent requirement of rapid, selective and accurate techniques for detecting pathogenic viruses, nano biosensors are developed. Nanotechnology based biosensors have found its way towards biological detection. Fluorescence resonance energy transfer (FRET) in association with Quantum dots (QDs) and their higher-level properties has enabled the designing of high-tech. biosensors. QD-FRET based nano sensors gained an immense popularity in various scientific areas for example virus detection, QD-FRET based immunoassays and pH sensors. In this review, we have discussed the latest novelties in the development of QD-FRET Nano sensors and their role in detection of viruses.

Key words: *Bio-sensors, Quantum dots-FRET, Nanoparticles.*

1. INTRODUCTION

In medical industry, there are sensors which have ample sensitivity which can detect diseases in their early state, the potential-live saving detection in high rates and their intervention [1]. There were several approaches that were made to build up the sensitivity of biomedical sensors. Nanobiotechnology is a vast field that incorporates science and engineering to probe the synthesis, properties and the structure and applications of materials and the critical dimension less than approximately 100nm [2]. As the size of the nanomaterial decreases to the nanometre scale, the physical and chemical composition are dominated by high surface to volume ratios which concludes in the nanomaterial having completely different composition as compared to the macroscale [3]. A nanostructure is ultrasensitive to the changes associated with its surface, which leads to the increase in the sensitivity of the device. In addition, the motion of electrons in the nanostructure is restricted by the appearance of the quantization effects. The foremost functions of biomedical applications ranging from disease diagnosis to drug delivery comprises detecting and characterization of chemical and biological species. For case, semiconductor nanocrystals and colloidal gold have been scrutinized and considered for detection of disease biomarkers and other biological species [5]. Optical nano biosensor is one of the important techniques in nano biosensing approaches because of its non-invasive nature, higher sensitivity, direct detection, and the easy coupling with other technologies [6, 7]. Some of the merits of the optical nano biosensor in virus detection are concluded as follows: 1. It is highly sensitive with super low limit of detection (LOD) 2. The design of naked eye readout assay for simple readout and fast diagnosis. 3. Cost effective of the testing instrument as there is a development of portable laser [8]. Therefore, in this review, we put in place the development of nano biosensors which have recently used for virus detection to be precise those integrate with OFM (organic fluorescent molecules), QDs (quantum dots), and gold nanoparticles (AuNPs).

2. WORKING PRINCIPLE OF OPTICAL NANO BIOSENSORS

The principle of optical nano biosensors primarily depends on the optical and luminescent characteristics of nanomaterials, luminescence resonance energy transfer (LRET) and the surface plasmons effects (SPs) as the nanomaterials like QDs, UNCPs and AuNPs have intrinsic luminescence or plasmonic optical absorption features [8]. LRET is the technique by which the energy is transported from the donor to the acceptor by using resonance interaction, which results in the declining of luminescence intensity of up donors and enhancing of receptors [8]. The surface plasmonic biosensors are extensively scrutinized in the fields of biotechnology, bioimaging and biochemistry are operated as sensing probes for infectious disease diagnosis, protein-DNA interactions, ion sensing and biological surface modification [9-11].

3. NANOSTRUCTURED OPTICAL BIOSENSORS

Nanotechnology is a branch of study which refers to the properties and applications of nanomaterials with sizes range of 1-100 nm. Having large surface to volume ratios of nanoplatforms, it is advantageous and is beneficial for the interaction with the surface analytes [12]. Based on their quantum confinement effect, multifunctionality and the flexibility in performance, in current scenario, there have been made progress in the field of virus detection based on the optical nanomaterials which are the current research arena and are aiming to reduce the cost and time of diagnosis.

4. QD-FRET BASED NANO BIOSENSOR

FRET (Förster resonance energy transfer) is the technique named after its inventor, a German scientist Theodor Förster. This technique will come into play where there is a presence of two fluorophores, the energy donor and receptor [13]. The non-radiative transfer of energy between donor and acceptor fluorophores is necessary in FRET which results in the long-range dipole-dipole interaction and photon emission is not included [13]. One of the most captivating nanomaterials are nanoparticles, especially Quantum dots (QDs). QDs are the semiconductors which are made with the elements of Group II and VI or Group III and V in periodic table.

Their size ranges between 1-10 nm and they are size dependent optical and are known for the electronic properties caused by quantum confinement [14]. There is one unique characteristic of QDs incomparable with organic fluorophores; the ability of tuning the emission range as a result of regulation of core size during synthesis and it follows quantum confinement [15, 16].

5. QD-FRET NANO BIOSENSORS ROLE IN DETECTION OF VIRUS

Viruses are infectious agents that have either DNA or RNA as their genetic material and they requisite a host organism for their living and replication. The genetic mutation in viruses is rapid and because of that, the diagnostics and therapeutic repercussions are very high [13]. Let us take an example of Porcine reproductive and respiratory syndrome virus (PRRSV), in this two different QD-FRET based nano biosensor have been put forward. 1. An anti-PRRSV monoclonal antibody which is labelled with Alexa Fluor 546 (A546) fluorescent dye which is associated with commercially modified-green QDs. 2. Anti- PRRSV monoclonal antibody coupled with protein A- modified gold particles [17]. Occurrence of antibody-antigen reaction will result in conformational changes which brings the FRET pair nearer and escalate its efficiency. The transport of energy from QDs to A546 is less, it results in the increasing of QDs photoluminescence and decreasing A546 fluorescence [17]. Another virus which can be detected by QD-FRET nano biosensors is Hepatitis B Virus (HBV) which has been reported of consisting of MPA-capped CdSe/ZnS QDs fused with amine-modified 15-mer oligonucleotides via carbodiimide chemistry along with Cy5 dye which is used for labelling of the target DNA. When bringing of QD-Cy5 FRET pair is together done by hybridization, fluorescence emission of Cy5 is observed [18]. The FRET signal is not produced by the non-complementary and unbound DNAs because they could not hybridize with the QD-DNA conjugate [18]. Human Enterovirus 71 (EV71) and Coxsackie virus B3 (CVB3) immunoassays are based on the energy transfer between two colour QDs and graphene oxide (GO) to be the donors and acceptors respectively. The limit of detection achieved.

Virus is also detected by QD-FRET based sensors **[20]**.

6. CONCLUSION

FRET has acquired a huge importance in the field of Nanobiotechnology, Biochemistry and in different research fields of detection sensitivity by various analytical techniques. FRET in collaboration with QDs and their higher-level properties to be precise, fluorescence lifetime has opened the doors for the development of new and improved biosensors. QD-FRET based sensors are providing an edge in the technology of miniaturization of the sensors and they are made so that they can be affordable and can be applied in everyday life in the future research aspects.

7. FUTURE PERSPECTIVES

We suggest that QD-FRET based nano biosensors can be used in the many fields of research and could play a key role in point-to-care diagnostics which is cost-effective, easy to available and easy to use and most important sensitive. With efficiency in in-vitro diagnosis it can also work under in-vivo diagnosis which can address the areas like target molecules, studying the changes in biochemical pathways.

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