Research and Application of Nano-Fluorescent Materials based on DNA

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Abstract. The genetic material of life is DNA, which sustains all the functions of life, the study of the relationship between DNA and life activities from the perspective of molecular level is very important for the diagnosis and treatment of genetic diseases. The DNA molecule has excellent recognition ability and self-assembly ability, and that is why it is used as a nanometre material to construct the accurate nano-structure, and then design the nano-structure with various functions. The structure is not only controllable, simple to be prepared, but also easy to achieve biological functionalization. And that is the reason why the development of biosensors of nano-fluorescent materials is rapid.

Key words: DNA; nanomaterials; biosensing; fluorescence.

1. Introduction
DNA [1] is closely related to many diseases of the human race. For example, if the components of some DNA are missing or increasing, it could lead to disease or the change of their genetic traits. In the DNA [2] segment, the sequence of nucleotide bases determines the genetic characteristics of the gene. DNA is widespread in organisms. Some important physiological processes, such as protein folding [3], cell apoptosis, drug molecule targeting, the transport and storage of bio-signal, are all dependent on the interaction of molecular recognition. The essence of recognition is the process of combining molecular selectivity that produce certain functions [4].

To be known by the outside world, the recognition process must have a signal output, and the background noise signal is required to be immune. In addition, it needs to be operable at different detection distances [5]. Therefore, the light signal becomes the most suitable signal [6], especially fluorescence. To be used as a sensing signal, fluorescence has the following advantages: it is detectable at long distance; it has high sensitivity; detection in situ technology, such as fluorescence imaging technology; switch operation is realizable, etc.

2. Nanomaterials
With the development of nanotechnology, the application of nanomaterials has become a research hot spot. The biocompatibility, high activity and microscopic properties of nanomaterials meet the needs of biosensors. Therefore, the application of nanomaterials in the biological sensor not only improve the sensitivity and selectivity of biological sensor effectively, but also enhance the detection signal of the sensor which provide a method to detect the sensitivity of the product. Now, more and more fluorescent biosensor [7] started using nanomaterials. Fluorescent biosensor has received widespread attention,
because they have many advantages, such as high sensitivity, simple, fast, low cost and low background signals. It has become a research area of fluorescent nanomaterials [8].

In the study of nanomaterials, Alivisatos and Mirkin demonstrated that nanoparticles have a higher sensitivity to DNA. We can improve the design of the sensor by combining the molecules, represent by DNA, with fluorescent materials and then improving the dispersion of nanomaterials through the surface functionalization of nanomaterials.

Observing the graphite under a microscope, Iijima found the Carbon molecules of the tubular coaxial nanotubes, now known as Carbon nanotubes (CNTs). According to the number of layers in the tube wall, (CNTS) can be divided into multi-walled carbon nanotubes (MWNTs), double-walled carbon nanotubes (DWNTS) and single-walled carbon nanotubes (SWNTS) [10]. Their length is generally within a range of several hundred nanometers to a few micrometers. Carbon nanotubes have unique electrical and optical properties, which make it able to be used as energy receptors in the transfer of fluorescence resonance energy, and as a very good fluorescence quenching agent. Besides, Carbon nanotubes has high fluorescence quenching efficiency because the absorption spectrum of it is wide.

The carbon quantum dot is a nanomaterial made by Clemson University for the first time. Metal quantum dots are obtained from a mixture of cadmium, silicon and lead, but they are toxic and hazardous to the environment. Compared with the metal quantum dots, the carbon quantum dots have little harm to the environment, no toxic effect and low preparation cost. Compared with the rare earth fluorescent nanoparticles, the carbon quantum dots have the advantages. For example, the carbon quantum dot has a large double photon, which can absorb the cross-section luminescence. It is easy to functionalization and its range is adjustable. Therefore, it has an incomparable development trend.

3. Analysis of fluorescence materials.

Fluorescent materials are divided into inorganic fluorescent materials and organic fluorescent materials. The research on fluorescent nanomaterials also has many directions, such as the selection of quantum dots in inorganic fluorescent materials, and the selection of organic small molecular materials in organic fluorescent materials. In the form of ligand modification, Ersoz first adds some molecularly imprinted material to the surface of the CdS based on self-assembly methods and then uses it for selective identification of DNA.

He used a new monomer to produce quantum dot nanomaterials, by using the properties that the new monomer interacts with template molecular, taking ethylene cool as cross-linking reagent and azobisisobutyronitrile as the initiator. Scatchard and Langmuir analyzed and verified the recognition performance of imprinted materials.

They believe that, based on the fluorescence properties of quantum dots and molecular imprinting technology, the application of quantum dots has a good development prospect.

Fluorescence analysis mainly includes fluorescence resonance energy transfer and fluorescence spectrometry. Fluorescence spectrometry refers to the analysis of target objects through the characteristics of substances, the wavelength of fluorescence spectra and the intensity of fluorescence. This method is highly selective and sensitive and has been used in the detection of biomolecules and metal ions. Fluorescence Resonance Energy Transfer (FRET) accelerates the progress of Fluorescence analysis technology. When the distance between the fluorescence donor and fluorescent receptors is within a certain requirement, the spectrum of donor is able to overlap the spectrum of receptor, the energy can be transferred according to the dipole interaction after the donor molecule is stimulated. The process that these energies transmit to the receptor molecules is called FRET phenomenon.

FRET can generate and build DNA detection sensors between graphene and fluorescein interfaces. When the fluorescein DNA probe was labeled before it is adhered by graphene, the fluorescein will produce FRET phenomenon after been stimulated the then quench the fluorescein fluorescence. After the probe identified the target fragment, double-stranded DNA structure will be formed, which will reduce the force between probe and graphene. When luciferin leaves the surface of the graphene, the fluorescence will be restored, allowing the detection of a part of the DNA fragment.
4. DNA fluorescence biosensor.
Fluorescent molecular probes combine molecular recognition with fluorescence technology. Through combining the specific receptors with the target molecules to molecular recognition and taking the corresponding fluorescence signal as a transmission mechanism, they can effectively convert the biometric information that represents molecular recognition into a fluorescent signal that is easier to detect. The performance indexes of fluorescent probes are mainly from the aspects of selectivity, sensitivity, in-situ detection and real time.

DNA biosensor is a technique used in nucleic acid sequence identification and detection. Its main principle is the Warson-Crick base pairing and nucleic acid molecular hybridization. DNA biosensors have DNA piezoelectric sensors, DNA fluorescence sensors, and DNA electrochemical sensors. By contrast, DNA fluorescence sensors with advantages like high sensitivity, good anti-jamming performance and the advantages of low expenses, is often used to base sequence detection, gene diagnosis, virus detection, DNA and protein analysis research in the form of structure, etc.

DNA fluorescence biosensors use optical fiber as a link base to convert chemical signals into observable fluorescent signals. The Piumno group studied DNA fluorescence biosensors, and Tyagi use fluorescence dimer and Picogreen as a fluorescent binding agent to detect whether the base is mismatched base on its property that it can be embedded into the DNA double strand. In addition, nucleic acid molecules can be screened in vitro to obtain the nucleic acid suitable for the ligand specificity. The nucleic acids could be obtained by the Systematic Evolution of Ligands by Exponential Enrichment (SELEE) technology.

5. Application prospect
The Study of the interactions among biomolecules and the unique structure of nano-fluorescence materials is a intersecting area of multi-disciplines, including nanotechnology, biology and chemistry. This research makes new materials in the life science more creative, it has become a new research trend, especially in molecular biology and it has played a huge role in the biological sensors and molecular diagnosis.

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