Commentary
Volume 12:12, 2021
DOI: 10.37421/jbsbe.2021.12.306

ISSN: 2155-6210

Journal of Biosensors & Bioelectronics

Open Access

Mechanism of Operation of a Nanosensor and Its Applications

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Commentary

There are several mechanisms that can convert a detection event into a measurable signal. In general, they utilize the sensitivity and other unique property of nanomaterial's to detect selectively bound analytes. Electrochemical nanosensors are based on detecting changes in the resistance of nanomaterial when the analytic binds due to changes in scattering or depletion or accumulation of charge carriers. One possibility is to use nanowires such as carbon nanotubes, conductive polymers, and metal oxide nanowires as gates for field effect transistors. Although they have not yet been proven in actual conditions until 2009. Chemical nanosensors include a chemical detection system. A physicochemical transducer in which a receptor interacts with an analyte to generate an electrical signal. In one case, the nonporous transducer showed a change in impedance when the analyte interacted with the receptor. This was determined as a sensor signal. Other examples include electromagnetic or plasmon nanosensors, spectroscopic nanosensors such as surface-enhanced Raman spectroscopy, magnetic electron or spintronics nanosensors, and mechanical nanosensors. Biological nanosensors consist of bio receptors and transducers. The selected transduction method is currently fluorescent due to its high sensitivity and relatively easy measurable potential. Measurements can be performed using the following methods: binding of active nanoparticles to active proteins in cells, use of site-directed mutagenesis to generate indicator proteins, enabling real-time measurements, or attachment. Creation of nanomaterial's with dots (such as Nano fibers) for baroreceptors. Even if electrochemical nanosensors can be used to measure intracellular properties, the lack of high specificity of bio receptors (antibodies, DNA, etc.) usually reduces the selectivity of biological measurements. The photonic device can also be used as a nano sensor to quantify the concentration of clinically relevant samples. One of the operating principles of these sensors is based on the chemical modulation of hydrogel film volumes, including Bragg gratings. When a hydrogel expands or contracts when chemically stimulated, the Bragg grating changes color and diffracts light of different wavelengths. Diffracted light can be correlated with the concentration of the target analyte. Another type of Nano sensor is one that works on a colorimetric basis. Here, the presence of the analyte causes a chemical reaction or morphological change, causing a visible color change. One such application is the ability to detect heavy metals using gold nanoparticles. Many harmful gases can also be detected by colorimetric changes, for example using commercially available Dragger tubes. They can be miniaturized for use in sample point devices, providing an alternative to bulky laboratory-scale systems. For example, many chemicals are regulated by the Environmental Protection Agency and require extensive testing to ensure that pollutant concentrations are within reasonable limits. Colorimetric nanosensors provide a way to measure many contaminants in the field.

Application

One of the first practical examples of synthetic nanosensors was created in 1999 by researchers at the Georgia Institute of Technology. A single particle was attached to the end of the carbon nanotube and the vibration frequency of the nanotube was measured both with and without the particle. The discrepancy between the two frequencies allowed researchers to measure the mass of attached particles. Since then, research on nanosensors has increased and the latest nanosensors have been developed for many applications.

Currently, nanosensor applications on the market include health care, defense, military, and other applications such as food, environment, and agriculture.

Defense and military

Nano science as a whole has many potential uses in the defense and military fields, including chemical detection, decontamination, and forensics. Some defense nanosensors under development include nanosensors for detecting explosives and toxic gases. Such nanosensors work on the principle that gas molecules can be distinguished based on their mass, for example using piezoelectric sensors. When gas molecules are adsorbed on the surface of the detector, the resonant frequency of the crystal changes, which can be measured as a change in electrical properties. In addition, field-effect transistors used as potentiometers can detect toxic gases if the gate is sensitive to them.

Food and environment

Nanosensors can improve various sub-areas of the food and environmental sector, including food processing, agriculture, air and water quality monitoring, packaging and transportation. With sensitivity, adjustability, and the resulting binding selectivity, nanosensors are extremely effective and can be developed for a variety of environmental applications. Such applications of nanosensors are useful for convenient, rapid and sensitive assessment of many types of environmental pollutants. Chemical sensors are useful for odor analysis and atmospheric gas detection from food samples. The "Electronic Nose" was developed in 1988 and used traditional sensors to measure the quality and freshness of food samples, but recently sensor films using Nanomaterials have been improved. The sample is placed in a chamber where the volatile compounds are concentrated in the gas phase, and the gas is pumped through the chamber to transport the aroma to the sensor. The sensor measures its unique fingerprint. The high surface area-to-volume ratio of nanomaterial's allows for stronger interaction with the analyze, and the fast response times of nanosensors allow for destructive reaction separation. Chemical sensors have also been constructed using nanotubes to detect various properties of gaseous molecules. Many sensors based on carbon nanotubes are designed as field effect transistors and take advantage of their sensitivity. The electrical conductivity of these nanotubes changes due to charge transfer and chemical doping by other molecules, making them detectable. To increase their selectivity, many of them incorporate systems in which nanosensors are constructed to have special pockets for different molecules. Carbon nanotubes have been used to measure the ionization of gaseous molecules, while titanium nanotubes have been used to detect hydrogen concentration in the atmosphere at the molecular level. Some of these were developed as field effect transistors, while others utilize optical sensing capabilities. The binding of selective analytes is detected by spectral shift or fluorescence modulation.

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Received 06 December 2021; **Accepted** 20 December 2021; **Published** 27 December 2021

How to cite this article: Yuehe Lin. "Mechanism of Operation of a Nanosensor and Its Applications." *J Biosens Bioelectron* 12 (2021): 306.