Bionic Nose to Detect Trace Amounts of Molecules [1]

For many diseases and afflictions such as cancer [2], respiratory infections, tuberculosis, and transplant rejection, early detection is crucial to begin life-saving treatments. Sensor [3] technology may offer a means to improve early detection for diseases. Sensors [4] have developed from gas chromatography [5] and mass spectroscopy to artificial mammalian olfaction systems, which are capable of recognizing the scent of disease in its early stages. As part of a cell’s metabolic processes, it emits a mixture of chemicals that evaporate and produce a distinct smell. Using gas chromatography [5] and mass spectroscopy to compare the metabolic chemical profile of known diseases is exceedingly time consuming and expensive. To reduce the cost and time for such analysis there is a need for research into the development of more complex and efficient sensor [3] systems [1]. Artificial olfaction [6] or bionic noses? utilize a variety of sensing methods, two of which are amperometric enzyme electrodes [7] and DNA hybridization biosensors [8]. Both sensors [4] incorporate carbon nanotubes [9] (CNTs [10]) into their design.

(Source: Dr. Kolmakov, Southern Illinois University at Carbondale)
Amperometric enzyme electrodes \[7\] function by measuring the reduction of oxygen as it moves towards the cathode of the biosensor in order to determine the concentration of a substrate in a biocatalyst (ex. remain glucose in relation to glucose oxidase). The correlation between the oxygen reduction rate and enzyme concentration offers a measure of the cellular metabolism. This testing method can be performed with a variety of biocatalysts \[11\] including alcohol oxidase, D- and L-amino acid oxidases, cholesterol oxidase, galactose oxidase, and urate oxidase, in order to create an enzymatic profile of the disease for identification and treatment \[12\]. Electrodes equipped with single wall carbon nanotubes \[9\] (SWNTs) and multi-walled carbon nanotubes \[9\] (MWNTs), exhibit faster reduction capabilities and increased sensitivity to the biomolecules due to the high conductivity of carbon nanotubes \[9\] \[6\]. When CNTs \[10\] are coated with nucleic acids they can also decrease the fouling effect on the sensor \[3\], in other words the CNTs \[10\] minimize the growth of biofilms on the sensor \[3\] after repeated use \[4,5\].

The second sensor \[3\] type is DNA hybridization biosensors \[8\], while similar in purpose and electrochemical basis to, amperometric enzyme electrodes \[7\], they utilize CNTs \[10\] to compare DNA similarity of a sample rather than enzyme concentration. DNA hybridization biosensors \[8\] use a single strand of DNA (sDNA) from a known disease to detect a given disease. It works by attaching the sDNS to an electrode using a CNT \[13\] then introduced to a sample. The sDNA of
the biosensor then binds to the sDNA of the sample in a hybridization event, measured using Manganese Mn(II) complexes. The compatibility of the two sDNA strands can help determine the identity of disease. Using CNT?s as the attachment mechanism improves the surface area of the electrode, and the electrode?s conductivity and sensitivity [2,3].

DNA hybridization biosensors

(Source: Rusling)

References


Author:

Abigail Howel [18]
Suzanne Johnson [19]

Development Stage:

- Off-Market [20]

Key Words:

- Artificial olfaction [6]
- Carbon Nanotubes [9]
- Amperometric enzyme electrodes [7]
- DNA hybridization biosensors [8]

Mechanism:

- Passive Nanostructure [21]

Benefit Summary:

Metal oxide [22] semiconductors [23] were used prior to bionic noses that rely upon CNTs [10]. The metal oxide [22] bionic noses were limited by the aging and required frequent recalibration. The metal oxides were too large to adequately imitate the olfactory system, as well as too costly. The two contemporary bionic noses, described above, incorporate electrochemical biosensors to detect certain cancers and other diseases using the metabolic emissions [24] of the diseased cells. This technology could also detect chemicals used in bombs, toxic fumes, and pollution in water [25] (3).

Risk Summary:

This technology has not yet been fully tested or developed, making many of the possible risks
unknown. Potential sources of risk include false positive results. If the computing ability of the sensors [4] is not advanced enough, the bionic nose could detect diseases that are not in its data library and mistakenly identify them as a similar disease.

Risk Characterization:

- **Uncertain** [26]

Risk Assessment:

- **Health Risks** [27]

Facility:

- **Medicine/Healthcare** [28]

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