

A new generation of eco-friendly carbon-nanotubes based chemiresistor for the rapid detection of ultralow concentrations of bacteria

PROJECT SUPERVISORS

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DESCRIPTION

Overview:

The aim of this project is to build a new generation of eco-friendly chemiresistor devices using carbon nanotubes in combination with a recognition element (antibody, aptamer or peptide) for the fast, selective and ultrasensitive detection of bacteria. Nanostructured materials have been successfully used in the last years for the construction of fast, accurate and sensitive biosensors, and in this project we aim to build, using as a support a material that inflicts minimal or no harm to the environment as paper, a sensing device to detect in a rapid and simple way ultralow concentrations of bacteria by measuring the change in electrical current (or electrical resistance) of the hybrid material aptamer-carbon nanotubes when the target bacteria is present in the sample to be measured.

Background and State of the Art:

Nanostructured materials have gained in the last years an increasing interest in the construction of biosensors. Nanostructured materials potentially offer a series of advantages like sensitivity, rapidness or accuracy, which are current demands of our society for the detection of many biological molecules like pathogenic bacterial cells. Traditional detection methods of bacterial cells generally require the use of cell culturing-based methods that can take up to several days to provide specific results. Therefore, there is a demand for fast, sensitive, selective, inexpensive and easy-to-use methods for detecting and quantifying pathogenic bacterial cells.

In this master project we propose the construction of a new generation of chemiresistors in which a dispersion of single-walled carbon nanotubes (SWCNTs) is deposited layer-by-layer^{1,2} over the paper that is the substrate of the device. In a chemiresistor the intensity of the electronic current flowing between two metal

electrodes placed at the distal ends of the device would be related to the concentration of the target analyte.³⁻⁵

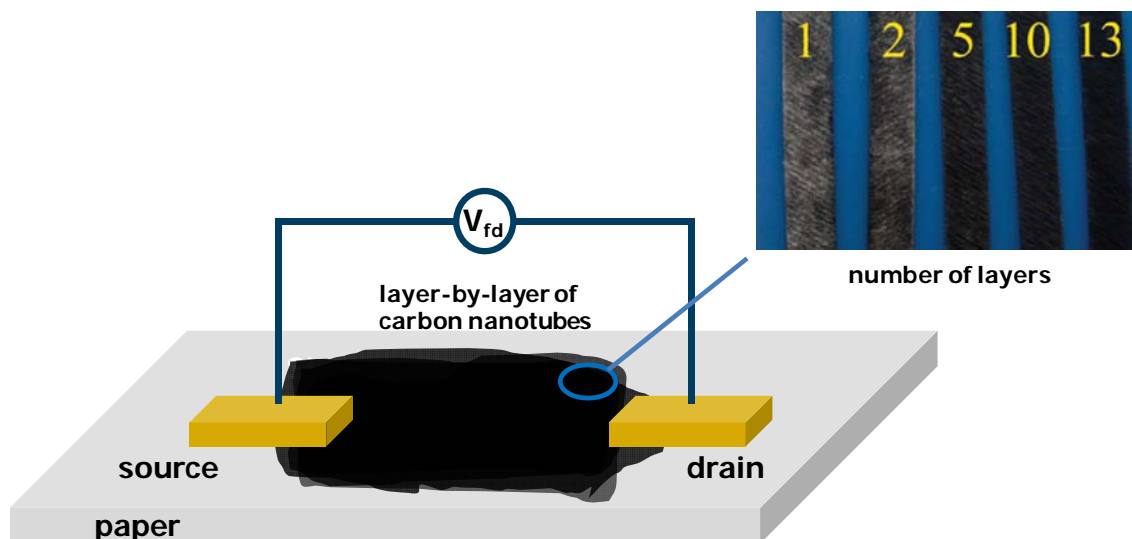


Figure 1. Scheme of the proposed chemiresistor

This device offers several advantages:

- low cost of fabrication, since we can use paper support.
- the device can be easily miniaturized so it can be converted in a fully point-of-care testing device.
- the device can be used by non-trained personnel since there are very few instrumental parameters to be controlled.

The transducing layer of the biosensor, the layer that converts the recognition event between the target analyte and the sensing layer into a measurable electrochemical signal will be made by several layers of SWCNTs. The sensing layer of the chemiresistor device, the part that will allow the selective detection of the target analyte can be based on antibodies or aptamers. Aptamers are artificial nucleic acid ligands (DNA or RNA), expressly generated against specific targets, that are characterized with a high affinity and specificity for their targets, comparable to, if not better than, their monoclonal antibody counterparts. Aptamer-based biosensors have proved their affectivity in rapid ultralow bacterial detection.⁶ Therefore, our chemiresistors could be developed with different aims: sensor for a whole bacteria family based on antibody as well as sensor for a specific bacteria strain based on aptamer. In addition, since other receptors are available (peptides and polysaccharides) the chemiresistor based on SWCNT should emerge as a detection method for a wide range of applications.

As a proof-of-concept of this new biosensing device, we intend to build a sensor for the fast, sensitive and selective detection of *Staphylococcus aureus* using a recently reported aptamer⁷ against this Gram-positive bacterium.

Project contribution and methodology:

The expected contribution to the state-of-the-art is a new generation of biosensors able to selectively and rapidly detect ultralow concentration of bacterial cells. Our research group (www.quimica.urv.cat/quimio/nanosensors) has all the facilities and the experience for the construction of biosensors. The experimental work will consist of the following steps:

- 1) Deposition of the SWCNTs/recognition element layer-by-layer over the paper substrate in order to obtain the conducting channel of the biosensor. The deposition will be obtained from a liquid dispersion of SWCNTs. The density and purity of the conducting channel are the main parameters to optimize.
- 2) Characterise the biosensor (electrically and with electronic microscopy).
- 3) Expose the biosensor to samples containing different concentrations of *Staphylococcus aureus*.
- 4) Validate the biosensor: sensitivity, limit of detection, selectivity in presence of interferences, blanks, etc.

Candidate profile:

Our group is looking for a master's student having sound knowledge of chemistry and preferably some background in biochemistry. The graduate will be able to design and conduct a research subject by him/herself, being able to find work both in academy and industry, specially in R&D positions.

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