

Design of a phenol biosensor based on carbon nanotubes

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Introduction

Biosensors represent an interesting alternative for the detection of phenolic compounds. Many different approaches can be found in the literature including carbon-paste biosensors [1], graphite composite electrodes [2], conducting polymer modified electrodes [3], and silica sol-gel composite films [4]. Some of these methods are relatively complicated, require the use of several reagents and often the biosensor produced presents stability problems. For that reason new alternative biosensor designs for phenolic compounds are being developed and investigated by our research group. These are based on screen-printed carbon electrodes modified with carbon nanotube.

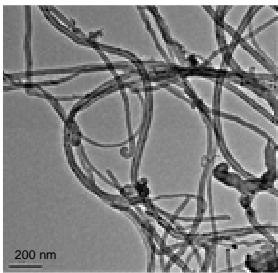
For a better understanding of the electrochemical response of the Tyrosinase-Multi-Walled Carbon Nanotubes based biosensors, it's necessary to characterize the morphology of the biosensing surface. Therefore, several techniques like Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM) and Confocal Microscope are used for such a purpose.

The adsorption technique used to modify the screen printed electrode with carbon nanotubes results the most interesting approach in relation to the preparation of tyrosinase-based biosensors for the analysis of phenolic compounds. Some preliminary results related to the electrochemical effect and morphology of the modified electrode will be shown.

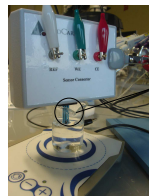
Results and discussions

Characterization

Previous characterizations of the CNTs used and the working electrode (WE) surface were carried out in order to achieve a better understanding of the biosensor performance. Firstly, carbon nanotubes dispersion was evaluated by TEM and their homogeneous distribution over the working electrode surface was studied by SEM. The distribution of the enzyme over the working electrode surface was studied by Confocal Microscopy.

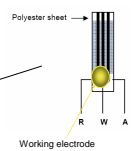


TEM image of the MWCNT purified and dispersed in THF (1mg of MWCNT/ 1ml THF)



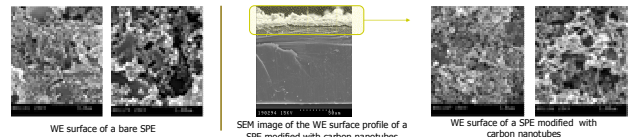
Working setup

Experiments are carried out in an electrolytic cell. Chronoamperometric studies are performed by a potentiostat (CH instrument, model CH1600C) in stirring and batch conditions.

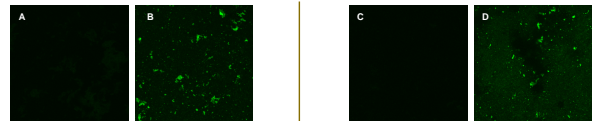


Schematic profile of the working electrode surface

SEM studies



Confocal Microscopy

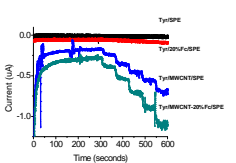


Images taken by Confocal Microscopy for Tyr/SPE (control experiment (A) and final confocal image taken in the fluorescent mode (B)) and Tyr/MWCNT/SPE (control experiment (C) and final confocal image taken in the fluorescent mode (D)). Control experiments demonstrate that the fluorescence shown in the image is only due to the tyrosinase presence.

Phenol measurements

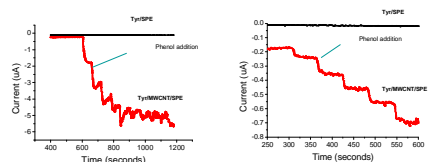
Optimization of the parameters

Effect of ferrocene used as mediator



Current-time recordings obtained from amperometric experiments performed in different SPE formulations

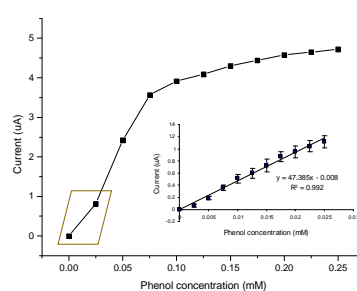
Carbon nanotubes effect



Responses at high phenol concentration range (25µM-250µM)

Low concentration range of phenol (2.5µM-25µM)

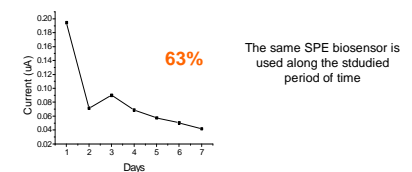
Analytical performance



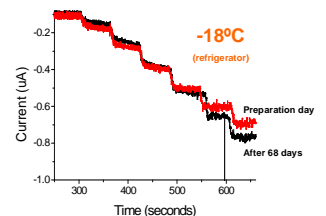
Detection limit = 1.35 µM
Sensitivity = 47.4 µA·mM⁻¹
Linear range = 2.5-75 µM

Stability studies

Stability study



Shelf lifetime study



Conclusions

Electrochemical analytical performances of the phenol biosensor were investigated in order to find the optimal fabrication design, but also to study the tyrosinase enzyme stability over the time. The adsorption technique used to modify the SPEs with MWCNTs and Tyr resulted promising in terms of cost, simplicity and analytical performances. A detection limit of 1.35µM and a sensitivity of 47.4 µA·mM⁻¹ within a linear range of response from 2.5 to 75µM phenol have been obtained.

The developed biosensors show very good performance for use as disposable devices although their lifetime while being saved in a freezer (-18°C) was excellent up to 2 months.

The application of these biosensors for phenol measurement in real sea waters samples is still under investigations at our laboratories.

References

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Acknowledgments

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