Carbon nanostructures based biosensors integrated into bioMEMS applied to biomedicine

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Introduction. Several kinds of electrical nanobiosensors have been proposed, using as transducers, nanowires (1), nanoparticles (2) or carbon nanotubes (3). We have recently proposed new kinds of nanobiosensors using nanoislands as high sensitive nanotransducers (4). The interest of implementing nanometric biosensors are justified due to the high sensitivity they have demonstrated. However, to construct high throughput arrays of nanobiosensors integrated with micro/nanfluidics, in the prospect of elaborating lab-on-chip devices and biomicroelectromechanical systems (bioMEMS), several issues have to be overcome such as the implementation of a reliable biochemical functionalization done onto exotic templates.
Here, we investigate the use of carbon nanostructures such as nanotubes and graphene, decorated with nanoparticles to validate specific biodetections via electrochemical, mass and optical sensing methodologies.

Methods. To test the conductivity of the different carbon nanostructures, we elaborated metal electrodes having different separations, as reported elsewhere (5). Local deposition of the carbon nanostructures has been performed via a microplotter (Sonoplot), obtaining microspots, onto the detection zone. The electrical measurements were done via an electrometer (keithley 4200-SCS) coupled to a probe station. Semiconducting carbon nanotubes have been tested without chemical functionalization, with a specific chemical functionalization and decorated with nanoparticles. On the other hand, voltametric, Surface Plamon Resonance (SPR) and Quartz Crystal Microbalance (QCM) have been employed to validate specific biodetections of DNA and homocysteine concentrations, adsorbed onto carbon nanostructures decorated with Pt nanoparticles. Several microscopy based methodologies were used to characterize the different steps.

Results. A direct methodology to immobilize polymorphism of DNA onto several types of thin films and carbon structures has been implemented, which was resolved by Atomic Force Microscope (AFM) and ellipsometry. Tests obtained by electrochemical technique were correlated properly to the different molar concentrations of homocysteine detected with carbon nanotubes decorated with Pt nanoparticles, as Fig. 1 illustrates.

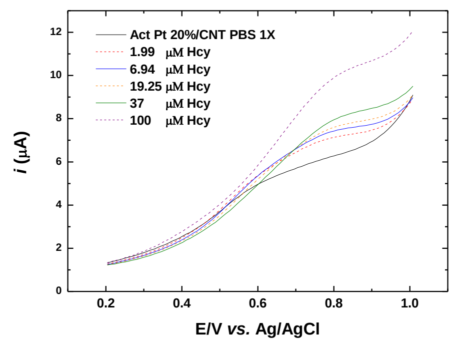

Fig.1 I-E characteristic as function of the homocysteine concentrations detection (PBS PH 7.4 with scanning rate of 5 mV/s).

Conclusions. We elaborated some microelectrodes to characterize electrically different types of carbon nanostructures with and without biomolecules and validated the biochemical functionalization. We used carbon nanostructures as transducers to detect concentrations of homocysteine implicated in cardiovascular diseases. Some methodologies were used to validate the biomolecular interaction. Thanks to voltametric technique and the use of carbon nanotubes decorated with Pt nanoparticles, it was possible to detect concentrations of homocysteine. These kinds of implementations have as purpose the elaboration of high sensitive nanobionsensors integrated into bioMEMS.

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